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Exploring the nature of the phonological deficit in dyslexia: are phonological representations impaired?

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Declaration

I hereby declare that this thesis is my own composition, that the work is my own unless otherwise acknowledged, and that the work has not been submitted for any other degree or qualification.

Catherine Dickie
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In memory of Mrs Mina Cartwright
'Whose faith follow'

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Abstract

Developmental dyslexia is widely believed to be caused either mainly or in part by an impairment of phonological representations. Although this hypothesis predicts that individuals with dyslexia should show deficits in tasks which require the use of implicit phonological knowledge, this has not yet been directly tested, as the evidence cited in support of this hypothesis usually comes from metalinguistic tasks which demand explicit awareness of phonological units. Additionally, since the ability to perform metalinguistic tasks which involve phonological segments can be enhanced by an individual's competence in alphabetic literacy, the possibility remains that phonological skills may have been inadequately isolated from the influences of literacy acquisition in many cases.

The study reported in this thesis investigated both the representations and the metalinguistic skills of a group of adults with a history of developmental dyslexia, examining areas of phonology which do and do not have orthographic counterparts. To isolate phonological skills from orthographic skills, the representations of conventional segmental contrasts (e.g. /k/ vs /g/) were compared with the representation of suprasegmental contrasts (as seen in minimal pairs such as *ˈtoy factory* and *toy ˈfactory*), which have no orthographic counterpart. Basic metalinguistic skills were tested by means of a phonological awareness task targeting both segmental and suprasegmental units, and phonological manipulation skills were tested using a Pig Latin task and a Spoonerism task, where participants were required to manipulate both segmental and suprasegmental units (e.g. extracting the segment /b/ from consonant clusters and the main stress from SWW or WSW stress patterns).

The results showed that although the performance of the dyslexic group was weaker than that of the control group when tasks required the manipulation of either the segmental or suprasegmental components of words, no evidence was found for a deficit in the tasks which drew on implicit representations or basic metalinguistic skills. These findings suggest that the phonological deficit in dyslexia may be restricted to the ability to manipulate phonological units rather than in the representation of them per se.

Chapter 1

General Introduction

1.1 Introduction

Within the bigger linguistic question of how best to understand phonological representations in the everyday speaker of any given language, there is a derived problem of how to understand impairments of phonological representations, whether for their own sake and with a view to informing therapy, or as a means of shedding further light on the nature of unimpaired phonological representations themselves. Among the many disorders of language, developmental dyslexia is an impairment which provides a particularly valuable opportunity to investigate issues of both impaired and unimpaired phonology – and especially, as a disorder of written language which is widely thought to be caused by a disorder of some aspects of spoken language, dyslexia raises many significant issues about the interface between spoken and written language and how both unimpaired and impaired phonological representations should be viewed.

The central concern of this thesis is the investigation of phonological representations in developmental dyslexia. This investigation is motivated by the hypothesis which has been widely accepted in the dyslexia literature, that dyslexia is caused either mainly or in part by a phonological deficit, and specifically by a deficit in phonological representations (the Phonological Deficit Hypothesis) (Snowling 2000). However, there are two difficulties with this hypothesis which this thesis aims to address. One is that the hypothesis seems to be insufficiently sensitive to the role of written language experience in shaping mental representations of spoken language, as much of the evidence which is cited in support of a deficit in phonological representations has been drawn from the performance of individuals with dyslexia in tasks which have not clearly isolated phonological skills from the potential influences of literacy acquisition. The other is that very little distinction is drawn within this hypothesis between the study of representations, as implicit knowledge which the language user does not need to be able to call to conscious inspection, and metalinguistic analysis, which does require the ability to reflect overtly or explicitly on various kinds of linguistic knowledge. It is argued therefore that in dyslexia the contributions of these different kinds of cognitive skills and abilities should be considered distinctly and independently of each other – implicit knowledge of the sounds of language should be distinguished from the ability to analyse auditory language material in terms of the properties of its form, and these both should be distinguished from proficiency in isolating particular units in spoken language and manipulating them in arbitrary ways.

In order to address these two considerations, two steps are taken. First of all, it is noted that suprasegmental aspects of English phonology are not systematically represented in English orthography, and, building on this observation, tasks are devised which take advantage of the opportunity which this feature of English provides to investigate the phonological representations of literate individuals without participants being able to make recourse to orthographic knowledge. Secondly, a range of different tasks is devised which test speakers' ability to draw on their implicit knowledge of the patterns of spoken language, their ability to undertake a basic metalinguistic analysis of the auditory material, and also their ability to isolate units and arbitrarily manipulate them in different ways. Each of these tasks is presented in both a segmental and a suprasegmental version, in order to permit inferences to be drawn about the similarities and differences between performance in the segmental (orthography-related) version and the suprasegmental (non-orthographic) version.

The outcome of comparing the performance of dyslexic and non-dyslexic participants in these tasks can briefly be summarised here ahead of the detailed presentation in subsequent chapters: although the performance of the dyslexic group was weaker than that of the control group when tasks require the manipulation of either the segmental or suprasegmental components of words, no evidence is found to suggest that there is a deficit in the tasks which draw on implicit representations of spoken words, or those which demand basic metalinguistic skills. It will be argued eventually therefore that when individuals with dyslexia are shown to have relatively weak performance in phonology-related tasks which involve the manipulation of arbitrarily defined phonological units, an explanation for this performance must be sought elsewhere than in phonological representations themselves (Chapter 6).

Meanwhile, in the present chapter I will begin by presenting an overview of current theories which make reference to the possible causes of developmental dyslexia, paying particular attention to the Phonological Deficit Hypothesis, which proposes a spoken language source for children's later written language difficulties (§1.2). Section 1.3 discusses the question of how spoken language and written language are related to one another, arguing that literacy needs to be recognised as having an impact on how spoken language develops. In §1.3.1, a closer examination of the claims of the Phonological Deficit Hypothesis will highlight some areas which require further investigation, in the light of this discussion. Section 1.4 presents the results of a pilot study which confirmed that there is a workable means of exploiting the properties of English suprasegmental phonology so as to test phonological representations independently of orthography. The chapter will conclude by offering a series of research questions (§1.5).

The remainder of the thesis is structured as follows. The research questions which are outlined in §1.5 will be tested in the four subsequent chapters: implicit spoken-language-specific representations in Chapter 2, basic metalinguistic skills in Chapter 3, manipulation skills as tested by a 'pig Latin' task in Chapter 4, and manipulation skills as tested by a spoonerism task in Chapter 5. The implications which arise from these two chapters will then be discussed in the concluding chapter, Chapter 6.

1.2 Current theories of the causes of developmental dyslexia

By way of background information before reviewing some of the main contemporary theories of the causes of dyslexia (§1.2.1 and §1.2.2), a brief overview of the manifestations of dyslexia will be useful. Developmental dyslexia is widely understood as an impairment characterised by a difficulty in learning to read and spell proficiently which is unexpected given the child's skill in other cognitive areas. In a recent review of the literature, Démonet, Taylor, and Chaix (2004: 1451) begin by defining dyslexia as "an unexpected, specific, and persistent failure to acquire efficient reading skills despite conventional instruction, adequate intelligence, and sociocultural opportunity." The formulations used by other researchers and organisations often vary slightly – some may invoke spelling and writing as well as reading skills, for example – but this definition provided by Démonet et al is characteristic of what has been adopted by a wide variety of researchers in the field: Ziegler and Goswami (2005: 15) adopt "the Organisation for Economic Cooperation and Development definition of a specific problem with reading and spelling that cannot be accounted for by low intelligence, poor educational opportunities, or obvious sensory damage such as profound deafness," Habib (2000: 2373) talks about children who "fail to learn to read in spite of normal intelligence, adequate environment and educational opportunities," and Ramus (2003: 212) states that "developmental dyslexia is a failure to acquire reading skills … despite adequate intelligence, education and social background."

Examples of how this kind of difficulty or failure in reading might manifest itself are provided by Snowling (2000). She reports that older children with dyslexia were observed to make errors such as saying 'sing' for *sign* and 'blow' for *bowl*, as well as 'fault' for *flood* and 'clot' for *choir* – errors which are similar to those made by younger, 6-7 year old typically developing children. A sample of writing from a dyslexic boy aged 10;8 is provided by McGhee (1996): "We sow lots of raddits and deaves foxs and lots of ufer animals…" ('We saw lots of rabbits and beavers, foxes and lots of other animals'), and from a dyslexic girl aged 12 (Hunter 1996): "I love animals and I hat wherking on the farm. My hoday are cook and swimin. I kleked lots of things and, I have 2 dogs and 2 cats wich I love" ('I love animals and I hate working on the farm. My hobbies are cooking and swimming. I collect lots of things and I have 2 dogs and 2 cats which I love'). Both the reading and spelling errors indicate that letter shapes may be confused, the order of letters may be transposed, words for reading may be partially sounded out and guessed at on the basis of sound similarity or plausibility in context, words may be spelled on the basis of how they sound or by mistaken analogy with similar sounding words, and so on.

The educational implications of these kinds of difficulties are clearly far-reaching, as the child's comprehension of texts is hampered when words are not well recognised in reading, and the presentation of their written work may be unconvincing when it is characterised by unconventional spellings, inconsistent spellings, messy handwriting, great effort, and in later years, weaknesses in planning and structuring longer pieces of work (Brown 1996). The process of reading, writing, or spelling is slower and more effortful in dyslexic children than their non-dyslexic peers. Lack of progress in the educational system can also have serious emotional and psychosocial implications for children who are less successful than their peers in acquiring literacy. Snowling (2002) reviews studies which have linked reading difficulties with lowered self-esteem, poor attention, and conduct disorder, although she points out that "the relationship between reading and behaviour differs according to gender and turns on the stage of development that is considered" (Snowling 2002: 690). Biggar and Barr (1996) review the experiences of twenty dyslexic children of primary and secondary school age who were referred to educational psychologists in the Dumfries and Galloway region: "[Children] report feelings of embarrassment, humiliation, shame, anxiety and guilt. They can feel stupid, useless, frustrated and angry. They lose confidence in themselves as learners …" (Biggar & Barr 1996: 383). Yet the children whose reading and spelling skills are typified by the examples above are also characterised by some kind of discrepancy in the overall profile of their cognitive abilities. This discrepancy may be identified statistically, by stipulating cut-off points in relation to IQ and reading scores, or as is increasingly more common it may be identified relative to each child, with literacy performance weaker than expected given the child's general knowledge, listening comprehension, and nonverbal problem-solving (Reid 1996; see also Pumfrey and Reason 1991: 214-216).

In addition to the hallmark impairment in reading and spelling, however, a wide range of further cognitive and behavioural skills have also been implicated in dyslexia. Many of these have been known for at least several decades, sometimes anecdotally, and others have been uncovered by specific groups of researchers with a particular interest in one aspect of dyslexia or another. In the visual domain, individuals with dyslexia may report seeing letters as if they were blurry or jumbled up or moving around on the page (Stein et al 2001). They may have difficulty with learning the months of the year and multiplication tables and remembering lists of instructions (McLoughlin et al 1994). Poor time management and lack of organisation are sometimes also cited, along with mixed handedness and difficulty telling left from right (Stein et al 2001). Smith-Spark et al (2004) found that university students with dyslexia reported more 'cognitive lapses' than controls, including forgetting what they went to the shops to buy, failing to notice signposts on the road, and daydreaming when they should be listening to something. It has also been found that if children with dyslexia are asked to walk along a raised beam they are more prone to be unsteady when doing another simultaneous task such as counting backwards (Nicolson and Fawcett 1990); they also show other signs of reduced dexterity and fluency such as being slower to thread beads onto a string (Nicolson and Fawcett 1994) and tapping their fingers in time to a metronome (Wolff 2002).

However, as Stein and Talcott (1999) point out, “we must emphasise that all the neurological problems that dyslexics face are mild” (Stein & Talcott 1999: 72). Stein (2001) cites several of the strengths which are sometimes attributed to individuals with dyslexia – “their talents are often described as holistic rather than linear, taking in the whole problem or scene statically at once and seeing possible solutions, rather than being confined to the conventional modes of thought that are small scale, sequential in space, time or logic” (Stein 2001: 30). Stein and Talcott (1999: 73) also point out that the success of famous gifted individuals in the past, “emphasises that difficulty with learning to read is not a wholly tragic life sentence,” but may well coexist with strengths and talents in other areas of school, work, and life.

Beyond observation of the manifestations of dyslexia, several theoretical accounts have also been proposed with the aim of explaining these symptoms by identifying the underlying cause (or causes) of dyslexia. The hypotheses which I will review here are the Phonological Deficit Hypothesis, the Magnocellular Hypothesis, the Cerebellar Hypothesis, and the Double Deficit Hypothesis.

1.2.1 The Phonological Deficit Hypothesis

The first of the theoretical explanations of dyslexia which I will consider is the Phonological Deficit Hypothesis, which is arguably the currently predominant view of the causes of dyslexia. Here I will outline the theory much as it is presented by its proponents, reserving detailed evaluation until the following section (§1.3).

The Phonological Deficit Hypothesis is outlined and defended most comprehensively and accessibly in Snowling (2000), but it takes its origins from at least as early as Stanovich (1988) and it provides a theoretical perspective which is shared by many different researchers in this area (Ramus 2003, Frith & Frith 1998, Brady 1997, Elbro, Borstrøm, & Petersen 1998, among others). The central claim of the Phonological Deficit Hypothesis is that the reading disability seen in dyslexia is caused by poor underlying phonological representations:

> "the deficit in dyslexia is in the way in which the brain codes or 'represents' the spoken attributes of words. In short, dyslexic readers have poorly specified phonological representations" (Snowling 2000: 35);

> "the proposal is that when dyslexic children come to learn to read, their phonological representations are 'fuzzy'. At the least, this causes a delay in the acquisition of reading … Very often, however, atypical development of phonological reading and spelling strategies ensues" (Snowling & Nation 1997: 154).

The same claim is made very explicitly by Ramus and his colleagues in various articles:

> "The specific reading retardation characteristic of dyslexia is directly and exclusively caused by a cognitive deficit that is specific to the representation and processing of speech sounds" (Ramus 2003: 212).

Similarly, according to Ramus (2001: 198), reading disability "results from a specific impairment of phonological representations and processes," or conversely, "a phonological deficit directly causes the reading impairment in dyslexia" (Ramus, Pidgeon, & Frith 2003: 720). This deficit is said to be an underlying one, which surfaces at the time when children learn to read and write (Snowling 2000), and the literacy difficulties are the most obvious manifestation of this underlying deficit (Ramus 2006: 261).[1]

The link which is proposed by this theory to hold between phonological representations and literacy is that the acquisition of the grapheme-to-phoneme principle is hampered by inadequately specified representations of the necessary phonological units. A more detailed discussion of the grapheme-to-phoneme principle will be provided in §1.3.2.2 below, but for the time being, it will be sufficient to say that within the Phonological Deficit Hypothesis, reading acquisition is seen as a process of mapping orthographic units to phonological segments, and as Snowling and Nation (1997: 153-154) explain, "having well-specified representations allows a child to set up fine-grained links between the orthographic representations corresponding to written words and the phonological forms of spoken words."

According to the proponents of this theory, phonological representations are the foundation on which a variety of other skills are based – Snowling (2000) shows skills as diverse as paired associate learning and nonword repetition, as well as reading and phonological awareness, as all causally dependent on phonological representations. Verbal short-term memory is also seen as phonological, due to the view that it comprises a memory buffer of phonological information, and hence that short-term memory tasks presumably rely on intact phonological representations in order to be performed successfully. These skills are often subsumed under the rubric of 'phonological processing,' a term which can cover almost any cognitive activity which has some connection with speech-related sounds, including

[1] The claim of the Phonological Deficit Hypothesis that the phonological deficit is the exclusive cause of dyslexia is complemented by the claim that the incidence of phonological deficits in individuals with dyslexia is 100%: "a deficit in phonological processing remains the most consistent finding in all studies of dyslexia, as confirmed again by our recent study that showed that 100% of the dyslexic sample were affected" (Ramus 2003: 215 (referring to Ramus, Rosen et al 2003)).

phonological awareness and the retrieval of names of words,[2] but although the Phonological Deficit Hypothesis is sometimes formulated as a deficit in both phonological representations and phonological processing, its proponents are very clear that the processing deficits are an outcome of the representations deficit. Snowling and Nation (1997: 154), for example, state that "dyslexic children have deficits in the representation of phonological information and not just in the conscious awareness of such information …" That is, it is when the underlying phonological representations are impaired that the effects of this impairment can be seen in weak performance in the other cognitive areas putatively tapped by these tasks. The two main strands of the Phonological Deficit Hypothesis are, therefore, that individuals with dyslexia have a deficit in their phonological representations, and also that this deficit causally underlies their reading difficulty.

A variety of kinds of evidence has been brought forward in support of the Phonological Deficit Hypothesis. The various sources cited by Stanovich (1988), for example, include investigations of phonemic phonological awareness, naming skills, short-term memory, and categorical perception of at least some phonemes. Approximately the same list is provided by Snowling (1995) and Snowling and Nation (1997), who cite phonological awareness, verbal short-term memory, long-term verbal learning (of the months of the year and also paired-associate learning), and verbal repetition. In the subsections which follow these pieces of evidence will be reviewed, again simply with a view to presenting the Phonological Deficit Hypothesis on its own terms, as a more detailed critique will be provided later (§1.3). Here I will group this evidence into three main types. The first type of evidence will be categorical perception studies, the second will be phonological awareness studies, and the third will be the other tasks named here which do not fit

[2] In fact, even nonword *reading* has been referred to as an example of phonological processing. This is presumably with reference to the 'phonological decoding/recoding' which it involves – in order to read aloud novel word-forms it is necessary to assign the appropriate sound-values to the letters which are presented – but this is 'phonology' in contrast with 'vision' or 'sight,' not phonology in the linguistic sense.

into ether of these classes (such as nonword repetition and naming tasks). These groupings reflect the closeness of the tasks in question to what might be called ‘phonological representations strictly understood,’ in the sense that, while they all have some phonology-related component in common, they vary (as will become clearer later) in the extent to which they can be said to reflect underlying, implicit, abstract mental representations of phonological knowledge.

1.2.1.1 Evidence from perception tasks

In categorical perception tasks, participants are required to assign stimuli which vary physically along some continuum to one cognitive category or another. In speech research, it has been known since the 1950s that human listeners have categories for /pa/ and /ba/, such that even when they listen to sounds which have been acoustically manipulated so as to be physically located somewhere between canonical /pa/ and canonical /ba/, the intermediate sounds are typically assigned to one of the categories or the other, imposing a two-category division on what is an acoustic continuum. This kind of information is relevant for investigating phonological representations in dyslexia because the particular way in which individual participants carry out the categorisation of the sound stimuli can (under certain assumptions) be taken as evidence for how the categories are represented in their minds.

Mody et al (1997) provide a review of several studies conducted throughout the 1980s, which show that individuals with dyslexia are less consistent than non-dyslexics in assigning speech stimuli to one category or another, on a variety of different phonological contrasts, such as /ba/-/da/, /da/-/ga/, and /sa/-/sta/ continua. Mody et al (1997) also cite studies which show that while dyslexics are less accurate than non-dyslexics on between-category discrimination, they are no less accurate than non-dyslexics on within-category discrimination – “suggesting that poor readers cannot easily exploit the phonological contrast that normally enhances discrimination across a phoneme boundary" (Mody et al 1997: 201). Breier et al (2001) presented a group of 21 dyslexics aged 7 to 16 years with a task where they were required to label stimuli as either 'ka' or 'ga' (on a /k/-/g/ voice onset time continuum), and found that as a group the dyslexics were less consistent than comparison groups. Serniclaes et al (2004) comment that as long as the phonemic categories are neither too difficult nor too easy for control groups to discriminate, a categorical perception deficit will be found among individuals with dyslexia, even if group differences are small, and only marginally significant (see also Manis et al's 1997 summary).

Recent studies have tended to confirm what is said by Mody et al (1997), although with some qualification. For instance, Adlard and Hazan (1998) tested thirteen reading disabled children aged between 9 and 12 years, and found that only a third of their sample showed what they called a 'weakness' in perceptual processing: the 'same/different' responses of the dyslexic group in a discrimination task were much less accurate than those of the other reading disabled children and of the control groups, and in their identification of phonemic contrasts, they were inconsistent with the end-points of the /d/-/g/ continuum, and on the /s/-/z/ continuum their responses were more or less random. Adlard and Hazan further point out that, rather than the data showing a clearcut discrimination deficit among the individuals in the dyslexic group, some of the same kinds of inaccurate and inconsistent response patterns were shown not only by isolated individuals from the remainder of the reading disabled group, but even by some of the controls – and indeed, two thirds of their dyslexic sample showed normal performance. This work has been extended by Messaoud-Galusi, Hazan, and Rosen (2007), who found that just over 40% of a group of 33 children with dyslexia in the 8-13 age range (and 80% of control children) performed within the 'normal' range on a /pi/-/bi/ continuum. Older children and teenagers were also tested by Manis et al (1997), in an investigation of phoneme identification. In their group of 25 dyslexics aged 10 to 15 years, the majority of the dyslexic children had normal phoneme identification (in a task where they were required to state whether the word was 'path' or 'bath', on a voice onset time continuum), but a minority of 7 individuals showed less sharply defined categorical perception when compared to age-matched controls. The authors suggest that the smallness of the difference between the groups may have been due to the conditions for the discrimination task being optimal – stimuli were not presented in noise, and working memory demands were minimised – and also perhaps due to the dyslexics being older children who had also received remediation.

When individuals with dyslexia can be shown to be impaired in categorical perception, therefore, one interpretation of such a finding would be that, with less well defined categories for phonemes, it would be harder for them to match graphemic or orthographic information with phonemic representations (under the view which sees reading acquisition as a process of mapping graphemes to phonemes). Typically these deficits are interpreted as evidence of less sharply drawn boundaries between phonemic categories. However, because of the uncertainty about whether categorical perception deficits characterise the dyslexic population as a whole, conclusions in the literature tend to be drawn tentatively. It has also been suggested that it is only under the pressure of other cognitive demands that linguistically relevant differences may appear between dyslexics and non-dyslexics (Manis et al 1997). Categorical perception deficits tend to be taken as one piece of evidence in favour of the phonological deficit for whatever subset of the dyslexic population show it (Snowling 2000), but it is generally accepted that the results of categorical perception studies, while "suggestive," do not seem to indicate that this deficit is integral to the manifestation of dyslexia or a necessary consequence of the hypothesised phonological representations deficit.

1.2.1.2 Evidence from phonological awareness tasks

A second strand of evidence which has been used to support the Phonological Representations Hypothesis is phonological awareness tasks.

Phonological awareness itself is defined as "conscious access to the phonemic level of the speech stream and some ability to cognitively manipulate representations at this level," (Stanovich 1986: 362) or "the ability to segment the consonants and vowels in words, and to be able to categorise words on the basis of these individual phonemic segments," (Brady 1997: 37-38). These two definitions are framed in terms of phonemes (or individual consonants and vowels), but the units which are accessed, segmented, or further manipulated, can also include whole syllables and the constituents of syllables, and a variety of operations can be carried out on whatever unit it may be – including counting, 'finishing off', odd-one-out, and deletion tasks.

Although there are differences among researchers in the details of how phonological awareness is related to reading, it is universally recognised that phonological awareness is an excellent predictor of reading success, with children's phonological awareness ability being consistently shown to be correlated with reading performance at later ages (see Bradley and Bryant's (1983) pioneering study, and reviews of the subsequent literature by Wagner and Torgesen (1987) and Snowling (2000)). Typically developing children are usually able to divide words into syllables from the age of about four years (Walley 1993), and to divide syllables into onsets and rimes any time between 4 years (Treiman 1992) and 6 years (Stanovich, Cunningham, and Cramer 1984). However, phonological awareness deficits have been found to characterise individuals with dyslexia throughout their childhood and into adolescence. Pratt and Brady (1988) found that in a task where phonemes or syllables were required to be deleted from a presented word, 9 year old poor readers made significantly more errors than good readers of the same age. In 'odd one out' tests on rimes and word onsets, 12 year old children with dyslexia have been found to make more errors than 8 year old reading level controls (references cited by Snowling 2000, p56). Fawcett and Nicolson (1995) gave tasks of phoneme deletion and sound categorisation to three groups of children, aged 8, 13, and 17 years. The sound categorisation tasks consisted of presenting the participants with two CVC words and asking them whether the words shared either the rhyme, the vowel, or the first consonant, and the children and teenagers with dyslexia performed these tasks with significantly less accuracy than both reading age and chronological age controls.

Various studies have also shown that these or similar deficits persist into adulthood. Bruck (1992) found that adults with dyslexia performed significantly less successfully than their age controls and reading controls on tasks such as syllable counting, phoneme counting, and phoneme deletion. Pratt and Brady's (1988) study also found that adults with dyslexia had difficulty with phoneme and syllable deletion, and a phoneme deletion deficit was shown by a homogeneous group of dyslexic university students by Wilson and Lesaux (2001). Other studies have used more complex tasks to test phonological awareness skills in adults. Pennington, van Orden, Smith, Green, and Haith (1990) found that dyslexic adults performed significantly worse than both reading age and chronological age controls on a 'pig Latin' task, a task which involves the movement of a word's initial phoneme to the onset of an additional syllable nucleus attached to the end of the word (eg *blend* becomes *lend-bey*). Gottardo, Siegel, and Stanovich (1997) also found that adult poor readers showed a deficit relative to adult good readers on a modified version of the same pig Latin task, as well as on a less demanding test of phoneme and syllable deletion. College students with dyslexia who were tested by Downey, Snyder, and Hill (2000) also showed reduced accuracy relative to controls in a pig Latin task, a similar finding to what was reported by Birch and Chase (2004) for college students with dyslexia whose spelling and reading scores remained uncompensated and below the normal range. Another complex phonological awareness task is the spoonerism task, where participants are required to exchange the initial phonemes of pairs of presented words (eg *basket*, *lemon* becomes *lasket*, *bemon*). Spoonerism deficits have been found in adults with dyslexia in several studies, including Gallagher, Laxon, Armstrong, and Frith (1996), Hatcher, Snowling, and Griffiths (2002), Judge, Caravolas, and Knox (2006), Ramus, Rosen, Dakin, Day, Castellote, White, and Frith (2003), Snowling, Nation, Moxham, Gallagher, and Frith (1997), Wilson and Lesaux (2001), and also (with small groups of participants) by Brunswick, McCrory, Price, Frith, and Frith (1999). Common to all these studies is the feature that their participants were adults who were either studying at university or about to enter university, and whose reading performance had improved to within normal levels, a finding which is generally taken to strengthen the claim that the phonological deficit is an underlying and primary symptom, which continues to evidence itself even when the reading deficit is no longer apparent.

It may be noted though that the tasks which continue to differentiate dyslexics from controls in adulthood are often more challenging than those which simply require participants to count units in words, or identify similarities and differences between units. Although tasks such as spoonerisms and the pig Latin task are typically considered under the rubric of phonological awareness, it is possible and perhaps preferable to consider them as falling into a category of their own which is distinct from the less challenging phonological awareness tasks. In this way tasks which require the ‘manipulation’ (movement, exchange, substitution, or other modification) of the phonological units could be considered as a different category from the more straightforward tasks such as rhyming and alliteration tasks, where the units are only identified, i.e., matched or counted. This distinction will become more important later (§1.3.3, §1.5).

The significance of phonological awareness deficits in terms of their interpretation within the Phonological Deficit Hypothesis is that they are generally taken as evidence of poor phonological representations: “difficulties in acquiring phonological awareness and skill in alphabetic coding are believed to be due, in many cases, to weak phonological coding characterised by poorly specified phonological representations” (Vellutino, Fletcher, Snowling, & Scanlon 2004: 12); “performance in phonological awareness tasks is … thought to provide an index of the representational adequacy of a child’s long-term phonological representations” (Thomson, Richardson, & Goswami 2005: 1212). As Swan and Goswami (1997a: 19) explain, the most widely held position is that,

> “an awareness of the phonological segments of words may not be as critical to success on phonological awareness tasks as the accuracy of the underlying phonological representations of the words … if the integrity of a subject’s output phonological representations are [sic] compromised, then it may not be surprising that the subject has difficulty performing segmental operations on those representations.”

1.2.1.3 Further sources of evidence

A third category of evidence has a bearing on cognitive skills which are more distant from phonology proper than are either of the two categories just considered – the data is drawn from tasks in which phonology does play some role, even though the tasks themselves address skills other than those that are directly phonological.

Individuals with dyslexia are known to show performance deficits in tasks where they are required to name pictures of an object, or an object which is described to them (see reviews in Snowling (2000)). These deficits are particularly evident when the words are long or infrequent (Katz 1986), or when there are time constraints on the naming task (Denckla & Rudel 1976), and typically the responses of individuals with dyslexia are either slower or less accurate than those of controls. Although, as we will see below (§1.2.2.3), a somewhat different interpretation has been put on the speeded naming deficit by other groups of researchers, the construction which the

Phonological Deficit Hypothesis puts on this evidence is to argue that since these children do not show any impairment of semantics or general receptive vocabulary knowledge, the reason for their difficulty in retrieving the names of these familiar objects must be phonological, and specifically, due to an impairment in the phonological representations of these words.

It has also been found that individuals with dyslexia are less accurate in nonword repetition tasks than their typically developing peers. Roodenrys and Stokes (2001) showed that 8 year old children with dyslexia were significantly less accurate than chronological age controls on nonword repetition and they also had a significantly shorter memory span as measured by both monosyllabic words and nonwords. Similarly Adlard and Hazan (1998)'s study of 9-12 year old children with dyslexia found that the repetitions of the dyslexic group were significantly less accurate than both reading age and chronological age controls. Nonword repetition deficits have also been reported in adults with dyslexia by Snowling et al (1997) and Gottardo et al (1997). A review of the role of working memory in dyslexia is also provided by Brady (1991), who suggests that the "efficiency of phonological coding" may be "an important factor in memory performance" (Brady 1991: 146). Snowling (2001) adds more detail to this interpretation when she suggests that since nonwords have no pre-existing representation in long-term memory or the lexicon, successful repetition is dependent on the quality of the phonological analysis which is applied to the nonword stimulus when it is heard, and the performance deficits seen in dyslexics are a result of their impaired phonological representations.

Several other types of task are reviewed by, for instance, Snowling (2001), Ramus et al (2003), Stanovich (1988), including paired association, word repetition, and alliteration fluency tasks, and in each case the rationale is similar to what has been outlined for the other tasks – the need for well specified, robust, and intact representation of the relevant phonological units is taken as a prerequisite for the successful performance of these tasks, and the fact that individuals with dyslexia show deficits on these tasks is therefore taken as evidence of fuzzy, degraded, or otherwise impaired phonological representations.

1.2.1.4 Summary

The review of the Phonological Deficit Hypothesis presented in this section has shown that the key components of this proposal are that phonology, broadly understood, is foundational to literacy; that the deficit underlying dyslexia is specific to phonology; and that the phonological deficit directly causes literacy impairment.

This section has also presented some of the most important sources of evidence which this hypothesis calls on for support, and although I will want (in §1.3.1) to challenge several aspects of the interpretation which the Phonological Representations Hypothesis puts on these different pieces of evidence, I will here restrict myself to acknowledging that on the basis of evidence such as has been presented here, it seems clear that there is at least some phonological aspect to developmental dyslexia.

1.2.2 Alternatives to the Phonological Deficit Hypothesis

If the Phonological Deficit Hypothesis is the currently dominant hypothesis of the causes of dyslexia, it is far from the only available hypothesis. Here I review the three main contenders to this theory – the magnocellular theory, the cerebellar theory, and the double deficit theory, in turn.

1.2.2.1 The Magnocellular Theory

Under the magnocellular hypothesis, a difficulty with phonology is acknowledged to be "a major cause of reading problems" (Stein & Walsh 1997: 148), but doubt is cast on the possibility that this phonological deficit can explain all the problems which are encountered in dyslexia. There is a variety of deficits, including clumsiness, temporal sequencing difficulties, and poor spatial awareness, which are listed by Stein and Walsh (1997) as characterising many if not all individuals with dyslexia, yet none of them seem likely to arise from a phonological deficit. More importantly for the magnocellular theory is one particular cluster of skills and weaknesses found in dyslexics – those which centre on visual processing and the visual magnocellular system in particular.

A vision-based theory was historically the first explanation to be offered for the phenomenon of otherwise typically developing children who found it unaccountably difficult to acquire proficient literacy skills (it is to this explanation that terms such as 'word blindness' owe their origin). The visual deficits which were historically identified are now generally subsumed under the more targeted hypothesis of the magnocellular theory, which, although it has precedence over the Phonological Deficit Hypothesis in this historical sense, is not currently as widely accepted as the Phonological Deficit Hypothesis. What the magnocellular theory does is to take the visual deficit as primary and also to attempt to integrate the visual deficit in a broader framework which seeks to explain both the visual and phonological deficits and the other deficits such as clumsiness and poor spatial awareness. In the domain of literacy itself, for instance, the proponents of this hypothesis cite the tendency for individuals with dyslexia to produce letter transpositions in spelling and phonologically implausible inaccuracies in single word reading. They suggest that this kind of difficulty is more straightforwardly attributable to a visual than a phonological deficit, but they also see it as important to recognise, and account for theoretically, the difficulties which are experienced by individuals with dyslexia outwith the domain of literacy:

> “[the problems associated with dyslexia] are not confined to reading, writing and spelling, but extend to incoordination, left-right confusions and poor sequencing in general in both temporal and spatial domains. These weaknesses all have their counterparts in the cognitive domain, so that dyslexics are notorious for having no sense of time and for difficulties with presenting a logical flow of argument” (Stein 2001: 13-14).

The claim is that the magnocellular hypothesis can account for all of this, and specifically, it is suggested that “reading problems are a consequence of impaired development of a system of large neurones in the brain (magnocells) which is responsible for timing sensory and motor events” (Stein, Talcott, & Witton 2001: 65).

Evidence in support of the magnocellular hypothesis comes from findings over the course of several studies that individuals with dyslexia differ from non-dyslexic peers in several functions of the visual magnocellular system: individuals with dyslexia have reduced sensitivity to spatial contrasts under some specific conditions (namely, where spatial resolution is low, luminance is low, and temporal resolution is high); they have shorter duration of visual persistence at high spatial frequencies; they have reduced sensitivity to flicker at low spatial frequencies; and they also have reduced sensitivity to coherent motion as measured by random dot kinematogram tasks (Stein et al (2001) referring to Talcott, Hansen, Assoku, and Stein (2000)).

These deficits are acknowledged to be mild, and evident perhaps only when large groups of participants are studied, and they are also acknowledged not to be present in all dyslexics without exception – approximately two-thirds of dyslexics are said to show visual magnocellular deficits (Stein, Talcott, & Walsh 2000). Nevertheless researchers in this area have made a strong case for the continuing relevance of visual impairments in dyslexia, explaining in detail several possible ways in which visual processing and reading could be linked. For instance, in successful reading, the reader's eyes fixate on each word for brief periods of approximately 300msec, before moving to the next word in a rapid jump or saccade. No details are available about the up-coming word during the saccade (all the information in the printed text is conveyed during the fixation), and during each saccade the image of the printed symbols moves around on the retina. For unimpaired readers, although the image moves on the retina, the print on the page is perceived as remaining stationary; but this is not so for dyslexics. Rather, unsteady fixations in dyslexia have the effect of making letters appear to move around on the page:

> "Because they were not intended, these eye movements would not be accompanied by corollary discharge indicating that the eyes had moved. Hence the image movements could easily be misinterpreted as the letters themselves moving, and their order and so forth could become confused" (Stein et al 2001: 73).

Having established the presence of deficits in visual motion sensitivity in at least some individuals with dyslexia, Stein (2001) brings various arguments together to suggest that a deficit in the magnocellular system is causally connected to dyslexics' reading deficits. According to Stein (2001), it has been shown not only that dyslexics have poor sensitivity to visual motion, but also that this relative insensitivity predicts their proficiency in spelling (i.e. irregular words and judging pseudo-homophones), and that visual motion sensitivity predicts their spelling skills independently of their ability to read nonsense words and produce spoonerisms.

However, some concerns have been raised in the literature as to the strength of the evidence in favour of a causal role for deficits in the magnocellular system. Foremost among the critics of the magnocellular hypothesis is Skottun (2000a, 2000b, 2005). Skottun (2000a) argues that although the standard method of distinguishing between the magnocellular and parvocellular systems is by means of contrast sensitivity tasks, there are inconsistencies among the studies which have investigated contrast sensitivity in dyslexia, in that not all studies show impaired sensitivity levels in individuals with dyslexia. He further characterises the magnocellular hypothesis for reading deficits as counter-intuitive, arguing that since neurons in the magnocellular system respond best to rapidly moving patterns of low spatial frequency, their specific relevance for a task such as reading (which involves the processing of stationary printed characters which are distinguishable primarily in their fine details) remains to be demonstrated. Additional studies, such as White, Milne, Rosen, Hansen, Swettenham, Frith, and Ramus (2006), have demonstrated that although it may be possible to attribute reading disability to visual factors in a minority of dyslexic children (six out of 23 in their sample), the visual impairment which they found to characterise these individuals was visual stress (such as is alleviated through the use of coloured overlays on printed text) – even though visual stress is not related to magnocellular function and is not thought to play any causal role in dyslexia.

A significant development of the magnocellular theory has been to extend its claims from the visual system (where magnocells are a distinct system with a well-established role) to also include the auditory processing system, which does not have a separate magnocellular system although like all the brain's sensory and motor systems it has magnocells which are specialised for processing temporal information (Stein 2001). Stein and Talcott (1999), for instance, suggest that there may also be a slight impairment of auditory sequencing skills in individuals with dyslexia "as a consequence of impaired development of magnocellular neurones in their auditory as well as their visual systems" (Stein & Talcott 1999: 70). Individuals with dyslexia have been found to be less sensitive than controls to the difference between pure tones and tones which have been modulated slightly in their amplitude or their frequency (Stein & MacAnally 1996), and sensitivity to these kinds of auditory transient stimuli has been shown to be highly correlated with nonword reading performance in adults with and without dyslexia (Witton, Talcott, Hansen, Richardson, Griffiths, Rees, Stein, & Green 1998). The argument of the proponents of the magnocellular theory is therefore that impaired magnocellular development in the visual system and also in auditory and motor systems will result in the mild but wide-ranging deficits which are seen in dyslexia in the visual, auditory, and also motor domains (Stein & Talcott 1999).

These adjustments to the theory make it more wide-ranging and ambitious, although critics continue to argue that its focus on visual magnocellular deficits fail to do justice to the variety of visual deficits observed in dyslexia (Skottun 2000b). The prevalence and significance of auditory perceptual deficits in dyslexia are also contentious (Ramus 2003, White et al 2006), and in common with many accounts which seek to relate what is physically and perceptually measurable to the linguistic structural system, the precise causal chain which would link auditory deficits to phonological impairment is not fully clear. While recognising the fruitfulness of the research enterprise built on the magnocellular hypothesis, therefore, some limitations in this account must also be acknowledged.

1.2.2.2 The Cerebellar Theory

In addition to the deficits which are emphasised by the Phonological Representations Hypothesis and the magnocellular theory, the cerebellar theory proposed by Nicolson and Fawcett (1995) is designed to provide a theoretical explanation for not only the phonological and visual deficits but also a further collection of impairments manifested by individuals with dyslexia. These are the findings that dyslexics also have deficits in skills such as balance and dexterity, which the proponents of this theory characterise as a difficulty in skill automatisation, and which, they argue, are the behavioural manifestations of a deficit in the cerebellum, the area of the brain which is responsible for developing fluency or automatisation in motor skills (Nicolson, Fawcett, & Dean 2001).

In the framework adopted by Nicolson and Fawcett and their colleagues, the reading and writing deficits in dyslexia are themselves conceptualised as an automatisation deficit: "dyslexic reading and writing performance appears more effortful, more prone to error, and more easily disrupted than normal performance. In short, to use a central concept from theoretical analyses of the acquisition of skill, it is poorly automatised" (Nicolson & Fawcett 1990: 181). This led them to pose the question of whether it is *only* reading and writing which are not fully automatised in dyslexia, or whether other skills could be described in the same way.

According to the definition, if a particular skill is fully automatised it "does not require conscious effortful monitoring and should show little or no decrement even if there are other demands upon conscious processing capacity" (Nicolson & Fawcett 1990: 163). To test the automatisation hypothesis, a set of skills which are clearly unrelated to reading and spelling were selected for investigation in individuals with dyslexia. Nicolson and his colleagues developed a dual-task paradigm – a paradigm in which subjects are required to perform a primary task (such as balancing on a beam) concurrently with a secondary task which is designed to demand conscious processing (such as counting backwards, or judging whether a computer-generated tone was 'high' or 'low'). If the skills demanded in the primary task are fully automatised, performance should not be affected when subjects perform the secondary task at the same time. In the 1990 study, Nicolson and Fawcett examined a group of 23 dyslexics (aged 11;6-14;6) and a control group of 8 children in the same chronological age range. The various primary tasks were all related to balance, and included, for example, balancing with one foot on a beam raised 6 inches off the floor, or walking up and down the beam without looking at their feet; the secondary tasks included counting backwards from 100 in twos, and judging whether a computer-generated tone was 'low' or 'high'. The results of this study were striking in that, regardless of how successfully the dyslexic children performed the primary task on its own, when they were required to do both the primary and secondary task simultaneously, their performance on the primary task was greatly more reduced than that of the controls. This hinted strongly at an automatisation deficit for the gross motor skills which were tested in this study, which now, according to Nicolson and his colleagues, required to be explained in conjunction with the deficit in automatising reading and writing skills.

On the basis of these and other findings (eg Fawcett et al's (1996) findings that dyslexics in adolescence and late childhood were significantly less successful than matched controls on a wide variety of tasks involving posture, muscle tone, and dexterity), it is argued that "dyslexic children have problems becoming automatic at any skill, irrespective of whether it is related to reading" (Nicolson 2001: 7). They also point out that accounts which see dyslexia as no more than a reading impairment cannot deal with findings such as these – and nor can a phonological explanation for the reading difficulties account for these broader deficits: "a verbal coding deficit … is clearly not relevant to gross motor balance, and neither is some more general language deficit" (Nicolson & Fawcett 1990: 176). On the other hand, it is claimed, the automatisation deficit theory includes a prediction that phonological deficits will be seen as part of the same general deficit, since the ability to "hear" the phonemes in a word is a learned skill, and something which non-dyslexic children can do automatically, in contrast to children with dyslexia (Nicolson & Fawcett 1995).

It is in the search for a neurological underpinning for the automatisation deficit that Nicolson and Fawcett have implicated the cerebellum – the suggestion is that the automatisation deficit is a behavioural manifestation of mild abnormalities in the cerebellum. Damage to the cerebellum is known to result in difficulties with posture and balance, limb rigidity, loss of muscle tone, and lack of coordination (Fawcett & Nicolson 2001, and the classic tests of cerebellar function, which Nicolson and Fawcett have used in their studies of dyslexia, have consistently shown the dyslexics to be impaired relative to controls, and with very high proportions of around 90% of the dyslexic groups manifesting these difficulties (see, e.g., the review by Miles and Miles (1999)). In Nicolson and Fawcett's account, however, the cerebellum is also implicated in the phonological and visual deficits in dyslexia. In addition to the balance impairment, the motor skill impairment, and problems with fluency, the impaired cerebellum is also argued to give rise to impaired articulatory skill and phonological awareness, which then leads to poor reading and poor spelling: Nicolson et al (2001) argue that lack of fluency from the earliest stages of infancy will have implications for dyslexics' articulation skills, which will result in reduced working memory, which will impair language acquisition, involving reduced sensitivity to phonological units such as onset and rhyme – in short, the cerebellar deficit they propose "accounts naturally for phonological deficit and for automatisation deficit" (Nicolson et al 2001: 510). In fact, they go on to argue that the cerebellar theory can also subsume both the magnocellular theory and the double deficit theory (which will be reviewed in the following section, 1.2.2.3).

The magnocellular theory and the cerebellar theory seem to be mutually sympathetic, although they do cover different areas. They also have in common a scepticism over the centrality of the phonological deficit, and a concern to see dyslexia as not just a reading deficit, but a constellation of difficulties which include reading impairment, and which require theoretical explanation in addition to the reading impairment itself.

1.2.2.3 The Double Deficit Hypothesis

The Double Deficit Hypothesis is proposed by Wolf and her colleagues. Its central claim is that a phonological deficit and a naming speed deficit constitute two independent sources of reading impairment. It also includes the claim that when only one of these deficits occur, the reading disability will be "modest or serious" (Wolf, Bowers, & Biddle 2000: 392), but that the most severely disabled readers will be those who are characterised by both deficits together.

This group of researchers retain it as a fundamental tenet of their research that "a child's ability to represent and manipulate the individual phonemes of the language in its spoken form is critical for learning the grapheme-phoneme correspondence rules that are the foundation for decoding, fluency, and comprehension" (Wolf, O'Rourke, Gidney, Lovett, Cirino, & Morris 2002: 44); or as they put it elsewhere, "phonological processes play an ineluctably important role in naming speed" (Wolf et al 2000: 395). To this extent, therefore, they follow in the footsteps of the Phonological Deficit Hypothesis, but their concern more particularly is that there is a great deal of heterogeneity in poor readers, and that, by concentrating on phonology alone, whether in research, diagnosis, or intervention, there is a danger of overlooking other relevant factors which might be helpful in understanding dyslexia and its causes.

The particular factor which they focus on is naming speed, which they argue is indicative of much more than phonology. Since the 1970s it has been demonstrated that children with dyslexia are slower than non-dyslexic children in rapid automatised naming (RAN) tasks, where they are required to name sequences of digits or colours or familiar pictures (eg a 5x10 matrix of common letters such as <p, o, d, a, s> repeated in random order) (Denckla & Rudel 1976). However, until the last few years it has generally been the case that naming speed was one of a large number of skills which were categorised under the label of phonological processing. It is this categorisation of naming speed as something phonological which the double deficit hypothesis challenges – there is no controversy as to the presence of a naming speed deficit in dyslexia, but the question of theoretical interest is whether it is more appropriate to attribute it to an independent deficit in rate of processing rather than to the standardly understood deficit in phonology. Wolf et al (2000) reject the position that subsumes naming-speed processes under the general rubric of phonological processes, saying that although naming speed does involve "accessing a phonological code," there is also a great deal of complexity in the cognitive demands associated with rapid naming tasks. To complete the earlier quotation from their 2000 article, they argue that "phonological processes play an ineluctably important role in naming speed, but represent only one component area among many" (Wolf et al 2000: 395). Some of these additional skills include visual processing, the integration of visual, orthographic, and phonological representations, semantic and phonological access and lexical integration, and finally motor articulation, all of which need to operate under pressure of time in a speeded naming (or a naming speed) task (Wolf & Bowers 1999); or as Jones et al (2008: 391) put it, rapid naming is "a deceptively complex task".

Evidence in support of the double deficit hypothesis comes from various sources. It has been found, for instance, that phonological awareness tasks alone do not predict reading skills as well as the combination of phonological awareness and naming speed (see studies referenced in Wolf et al (2000: 401), for instance). It has also been found that naming speed is a better predictor of reading performance than conventional 'phonological processing' tasks such as phoneme deletion, in languages such as German, Finnish, and Spanish, which have regular orthographies (Wolf & O'Brien 2001: 128). Problems in rate of processing are also found throughout the lifespan in individuals with dyslexia, from kindergarten through to adulthood (Wolf & O'Brien 2001: 130). More importantly, it has been found that naming speed deficits can occur independently of phonological deficits. Wolf et al (2002) tested a large sample of severely impaired readers (144 children, aged between 6;6 and 8;6) on a range of measures including rapid naming and phoneme elision and blending, with the specific aim of investigating whether, or to what extent, phonological awareness and naming speed would be independent. They found that both naming speed and phoneme deletion measures made unique contributions to the variance in the Woodcock Word Identification subtest (which tests performance in reading aloud high-frequency real words), and naming speed made a small independent contribution to the Woodcock Word Attack subtest (a nonword reading test). Both phoneme deletion and naming speed were also significant predictors of reading comprehension. A recent study by Jones et al (2008) which looked more deeply into the skills demanded by RAN tasks themselves has provided further confirmation that performance on this task is indeed affected by non-phonological processes in addition to phonological processes. Jones et al showed that naming speed on a RAN task was increased for adults with dyslexia both when the letters to be named were visually confusable (such as *p* and *q*, which are mirror images of each other), and also when the names of the letters were phonologically similar (such as *g* /dʒi/ and *j* /dʒe/, where the letter names share an onset). The performance of non-dyslexic controls was also seen to be affected both by the visual properties of the letters as well as the phonological properties of their names (although in the non-dyslexic group this was observable only in the details of their eye movements as measured by eye-tracking methods, rather than being also manifested in increased time to begin articulating the letter names).

Wolf and her colleagues are careful to say that their theory does not aim to be a complete account of all possible causes of reading impairment (Wolf et al 2002), but only an attempt to account for some of the heterogeneity of poor readers by identifying a realistic additional source of reading impairment. To show that this is indeed a realistic source they provide two hypotheses for how naming speed could be related to reading. In one hypothesis, naming speed and reading are related through orthographic processes: a naming speed deficit could prevent "amalgamation of the connections between phonemes and orthographic patterns," and/or limit "the quality of orthographic representations," and/or increase the amount of practice needed before an orthographic code is learned (Wolf et al 2000: 396). Alternatively, there could be "a more systematic failure in timing processes," manifested across visual, auditory, and motoric domains, not so much at the level of basic perceptual detection as "when some aspect of choice and integration of more than one set of sub-processes are required" (Wolf et al 2000: 398):

> "… the range of these findings invites but cannot be explained by a simple, across-the-board reaction time explanation. … no RT differences appear on single-task conditions at the most basic level of perceptual detection; rather, perceptual timing differences in dyslexic readers seem to occur when some

> aspect of choice and integration of more than one set of sub-processes are required. …The elements of choice and precise, temporal coordination – both of which contribute to the system's cognitive 'load' – appear to be necessary for the timing deficit to be evidenced." (Wolf et al 2000: 398-399)

The value of this theory lies not only in its greater sensitivity to the relationship between phonology and other cognitive skills, but also in the different and important implications it gives rise to for the diagnosis of dyslexia and intervention. It is perhaps not a contradiction of the phonological account, but it certainly aims to supplement it.

1.2.3 Summary of theoretical alternatives

This section has presented the claims of several different schools of thought as to the causes of developmental dyslexia. The Phonological Deficit Hypothesis suggests that dyslexia is caused by a specific impairment of phonological representations, and brings to bear several sources of evidence which will be reviewed in greater detail in the following section. The main alternatives to this hypothesis are the Magnocellular Theory, which suggests that deficits in the timing of sensory and motor events can be attributed to a deficit in the brain's magnocellular system; the Cerebellar Theory, which suggests that dyslexics' deficit in automatising skills can be explained by an impairment of the cerebellum; and the Double Deficit Theory, which suggests that naming speed is a second core deficit in dyslexia, in addition to phonology and independent of it.

One thing which these diverse alternatives to the Phonological Deficit Hypothesis have in common is that they challenge the *prominence* of the phonological deficit in dyslexia. In each case, they do not question that phonology plays *some* role, although they vary in how substantial a role they recognise – they only call for the recognition of a wider range of associated impairments. However, what unifies these theories in relation to the Phonological Deficit Hypothesis is of course what the proponents of the Phonological Deficit Hypothesis find most inadequate – that such importance is assigned to deficits other than the phonological deficit. It is common therefore for the Phonological Deficit Hypothesis to respond to these challenges by acknowledging that the Phonological Deficit Hypothesis does not aim to integrate the other deficits characteristic of dyslexia, and yet arguing that these additional deficits are not part of the "core" features of dyslexia, even though they may have a useful function as biological markers of dyslexia (Ramus 2003, Stanovich & Siegel 2000, Vellutino et al 2004).

1.3 Evaluation of the Phonological Deficit Hypothesis

Having presented a largely descriptive overview of the main theories of dyslexia in the previous section, this section turns to evaluate more directly the claims of the Phonological Deficit Hypothesis. In order to do this it will be necessary to begin with a discussion of the nature of the putative phonological deficit in dyslexia, so as to ascertain what in detail is meant by the claim that phonological representations in dyslexia are 'poor' (§1.3.1).

There will be three main strands to the critique of the Phonological Deficit Hypothesis which I offer here. Firstly (§1.3.2) I discuss the question of the causal claims which this hypothesis makes, especially in the light of the close and overlapping relationship which (I will argue) holds between spoken language and written language. I then (§1.3.3) raise the issue of metalinguistic skills, and discuss in more detail the quality of the evidence which is typically adduced in favour of a phonological representations deficit, questioning whether it is as directly relevant as it is often assumed to be. Thirdly, in §1.3.4 I will discuss whether there is any role for suprasegmental aspects of phonology in the Phonological Deficit Hypothesis, given that the hypothesis as it is currently formulated makes no mention of aspects of phonology which are not segmental. The section will then conclude (§1.3.5) with a brief summary of the questions which are raised by this discussion as a whole in relation to the phonological deficit in dyslexia.

1.3.1 The nature of the putative phonological deficit in dyslexia

In §1.2.1, the Phonological Deficit Hypothesis was reviewed in general terms, distinguishing it from the other causal theories which have been proposed for dyslexia. Here, the Phonological Deficit Hypothesis is examined in greater detail, with a view to pinning down how, precisely, the phonological deficit is to be understood. In this section I will present the points which arise both implicitly and explicitly from the proponents of the Phonological Deficit Hypothesis as to the nature of the phonological problem in dyslexia.

As we have seen, the Phonological Deficit Hypothesis traces all the phonology-related deficits seen in dyslexia back to phonological representations. This then raises the question of what, if phonological representations are 'poor,' is the precise nature of their poverty? What exactly is meant by saying that phonological representations are 'poor'? It has been pointed out by other researchers that in reading research in general as well as in dyslexia research in particular, it can seem that 'phonology' is a term which inconsistently covers a wide range of concepts: according to Uppstad and Tønnessen (2007), there is a great deal of vagueness in what the term refers to – it includes "partly letter sounds, the sound system, sounds in general, a language module in the brain, as well as mental units of sound"

(Uppstad & Tønnessen 2007: 158), and what Ramus (2001) identifies as 'outstanding questions' in the dyslexia field could no doubt from a more critical perspective be seen as fundamental issues which might have deserved to be addressed from the outset of a phonologically oriented research programme. This discussion will therefore proceed on the basis of the relatively undetailed hints and pointers in the literature as to how the phonology-related concepts and constructs which are invoked in the context of dyslexia should be understood.

In the broadest possible terms, phonology itself as invoked by the Phonological Deficit Hypothesis seems to be understood within a modular view of language, and with the assumption of symbolic mental representations. From his early papers onwards Stanovich has committed himself to following Fodor's modular view of cognition ("the key deficit in dyslexia must be a vertical faculty rather than a horizontal faculty" (Stanovich 1988: 601)), and a similar stance has been adopted by Snowling (2000), where language is described, following the view put forward in Pinker's *Language Instinct*, as a system,

> "made up of different sub-systems which interact during normal communication. … The building-blocks of language are … within the syntactic system, which is concerned with grammar and sentence-level processing, and the phonological system, which maps speech sounds to units of meaning" (Snowling 2000: 34).3

Indeed, Frith and Frith (1998) have explicitly proposed that dyslexia, as a disorder hypothesised to be specific to phonology, provides evidence in favour of modularity. They suggest that there is a phonological module which is responsible for the "processing, editing and coordination of subsyllabic and whole word sound information" (Frith & Frith 1998: 6), and it is when this module is absent, deviant, or

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[3] In their thoughtful if trenchant critique of the role of phonology in dyslexia, Uppstad and Tønnessen (2007) demonstrate how indebted the earliest work on the cognitive aspects of dyslexia is to several of the key assumptions of autonomous linguistics, including the assumption that what is physically observable should be attributed to an abstract underlying linguistic system, the tendency to equate linguistic descriptions with mental processes, and the identification of what is spoken as 'linguistic' to the exclusion of what is written.

damaged in some way that an individual will be impaired in their ability to learn to speak or acquire language, with knock-on effects on literacy acquisition.

It is furthermore clear from the literature that *phonological representations* is certainly the locus identified in the phonological deficit hypothesis for what this theory regards as the core deficit in dyslexia: "dyslexic children have deficits in the representation of phonological information and not just in the conscious awareness of such information," according to Snowling and Nation (1997: 154); "the proposal is that when dyslexic children come to learn to read, their phonological representations are 'fuzzy'." Similarly, the summary explanation of the deficit in phonological representations provided in Snowling (2000) says that "the images of the sounds of words stored in a dyslexic brain are fuzzy or blurred" (Snowling 2000: 215).

It is also clear that there is a consensus that terms such as fuzziness, impairment, degradation, weakness, and so on, are appropriate descriptors for the phonological representations that individuals with dyslexia are possessed of. 'Weak' phonological representations are identified by Dietrich and Brady (2001) in their study of adult poor readers, because they were less accurate than controls in word reading and more inconsistent in their realisations of the same word ("e.g., producing *stethoscope* as 'stefoscope' on one occasion and 'sethoscope' on another")[4]. 'Indistinct' phonological representations are identified by Elbro, Borstrøm, and Petersen (1998) and Elbro and Pallesen (2002) in their studies of children with and at risk of dyslexia, when their pronunciation of the vowels in polysyllabic words included more deletions and reductions or assimilations than that of their peers.

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[4] It is not clear whether so-called th-fronting (substituting [f] for [θ]) is a characteristic of the local variety or not – if so, it would clearly not be an erroneous production, since both options would be available in the speakers' repertoires, and variability of production would likely reflect social factors rather than a weakness of phonological representations.

Yet what this weakness, indistinctness, or fuzziness might consist of, in terms which would link with the existing theoretical phonology literature, is not fully explored. For instance, Bernhardt and Gilbert (1992) spell out some developmental implications of accepting the notions of the feature hierarchy and underspecification, as these are understood in contemporary nonlinear phonology. They suggest, for example, that features which are more deeply embedded in the feature hierarchy will be acquired later than those which belong at higher levels, and that children should be seen to gradually add specified values to underspecified 'default' segments. It could, perhaps, be possible to construe 'indistinct' or 'fuzzy' representations as instances of feature underspecification in this technical sense, or evidence of the late acquisition of features far down in the hierarchy – but too much importance should not be attached to such superficial points of resemblance too hastily. Bernhardt and Gilbert (1992) explain that deeply embedded features include "details of place or glottis," while featural underspecification might be exemplified by the child's use of 'default' segments, and it is far from clear that dyslexic children's phonology can be characterised by a late or abnormal acquisition of place or voice features, or excessive over- or under-generalisation of the feature specifications being acquired. This is simply not the sort of question that is addressed in the literature which deals with the phonological representations of individuals with dyslexia. Without necessarily endorsing the details of the particular theoretical approach which Bernhardt and Gilbert advocate, the point here is that commitment to a robust understanding of phonological representations, and a robust exposition of the putative phonological representations deficit, would surely be demonstrated by making reference to models such as this in the literature on phonological impairments other than dyslexia.[5]

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[5] It is of course more than possible that theoretical phonology might be inadequate or inappropriate for handling the phonological representations impairments which are claimed to exist in dyslexia. But this needs to be explicitly demonstrated in the dyslexia literature, and all the more so, since the theoretical background of the Phonological Deficit Hypothesis is generically Chomskyan, modular, and mentalistic, just like most mainstream contemporary theoretical phonology.

In fact the most concrete the proposals seem to be made is indicated in the following excerpt from Snowling and Nation (1997), where it is argued that the failure in reading acquisition is caused by the phonological representations which children bring to the task of reading, and which are poorly specified *in that they are not phonemic*:

> "developmental phonological dyslexia characterises children with more severe phonological deficits who have poorly specified phonological representations. When these children come to learn to read, they are forced to develop mappings between orthographic and phonological representations that are coarse-grained. Formally, it is because the mappings are not at the phonemic level of representation that sub-lexical mappings do not develop; thus, the ability of these children to read words does not generalise to allow them to read words they have not encountered before, as usually assessed by non-word reading" (Snowling & Nation 1997: 159).

That is, the phonological deficit is explicated as a representations deficit, and the representations deficit is presented as an inadequacy of phonemic segmentation, and this deficit in phonemic representation is attributed to the child before he or she comes to learn to read and write.

Now that these essential elements of the hypothesis have been set out, the following subsections will discuss the various issues which pose difficulties of one sort or another for this hypothesis, beginning with the question of the relationship between spoken language and written language.

1.3.2 The overlap between spoken and written language

The fact that the Phonological Deficit Hypothesis claims to explain a deficit in written language by reference to a deficit in aspects of spoken language makes it important to establish what kind of relationship holds between spoken and written language. Any hypothesis which seeks to relate the two has to face the challenge of how to reconcile the observation that while the conventions of written language differ in many significant ways from the conventions of spoken language, the two modalities nevertheless have a great deal in common. Given that the speakers and listeners whose utterances are the focus of phonological investigation are also readers and writers, it is particularly important in studies of literacy impairment to recognise that literacy has an impact on spoken language which extends to mental representations. After discussing this overlap, I will show how the closeness of the relationship between spoken and written language is inadequately accommodated within the Phonological Deficit Hypothesis, particularly in relation to the causal claims that it makes.

1.3.2.1 Segments and alphabeticism

Literacy and writing are not conventionally regarded as being part of the remit of the discipline of linguistics, which is supposed to focus on spoken language exclusively. It is generally believed that it is straightforward to isolate spoken language from written language, so that linguistics can concentrate on the analysis of spoken language, and the study of written language can be handed over to disciplines other than linguistics. It is also often believed that language users have purely linguistic mental representations of language – representations which have linguistic properties but which are free from any other kind of information, even information arising from written language, which might seem pre-theoretically fairly close to linguistic information. Yet in this section I will seek to query whether it is after all legitimate for linguists to postulate mental representations which contain purely (spoken) linguistic information – is it really the case that spoken and written language are completely separate phenomena, or should we understand instead that there is some sort of two-way, or mutually influencing, relationship between them.

One view of the relationship between spoken language and writing, and perhaps the prevailing view within linguistics, is expressed in the claim that people use alphabets because alphabets represent the language system in their minds: language users put onto paper the segments which already exist in their mental representations of spoken language. "You might say that speakers are influenced by the written language," says Shane (1973), "but alphabetic writing can in fact be used as one argument in favour of the segmental view of speech, since with such writing systems there is a correlation between a sequence of graphic symbols and a purported sequence of speech sounds" (Shane 1973: 3-4). The same view is expressed by various other writers (e.g., Adams 1990, Pinker 1994).

On the other hand, dissatisfaction with this view has been expressed in several ways from various different quarters (Abercrombie 1991: §3-4, Firth 1957, Harris 2000, Householder 1971: §13, Linell 1982, Lüdtke 1969, Twaddell 1935, Vachek 1989). Specifically with reference to phonology, there has been a persistent undercurrent of opinion which has in various ways voiced the claim that the speech stream would never have been conceived as consisting of units such as phonemes or segments if we had not had orthography to model it on (see e.g. Silverman (2006), among others). While in the great majority of contemporary phonological theories units are simply a given, a large and diverse body of phonologists and phoneticians turns out to have identified alphabetic literacy as the source of the pervasive belief that segments are necessary in phonology. According to Derwing (1992: 200), "the orthographic norms of a given speech community may play a large role in fixing what the appropriate scope is for these discrete, repeated units into which the semi-continuous, infinitely varying physical speech wave is actually broken down." More recently this same position has been articulated from different perspectives with some frequency (Port & Leary 2005, Silverman 2006, Port 2007, Lodge 2007), and also by Ladefoged (2005), who concludes his comments on the strong influence which writing has on how we think about the sounds of speech with the suggestion that, in the end, even consonants and vowels could be considered as "largely figments of our good scientific imaginations" (Ladefoged 2005: 191).

There is indeed a variety of pieces of empirical evidence which throws serious doubt on the claim that writing is a reflection of pre-existing mental representations of spoken language, at least in its strong but popular form. Several sources of evidence can be drawn on to support the view that literacy affects language knowledge in significant and far-reaching ways – ways which have perhaps been insufficiently regarded in the context of phonology and the reading impairment in dyslexia. Specifically, I will now discuss in turn the evidence which comes from children's development, literate and non-literate adults, and individuals familiar with different orthographies.

As was already mentioned (§1.2.1.2), children's spontaneous segmentation of spoken language develops from phrase- and word-level units to syllables, then onsets and rimes (Walley 1993). According to Velleman and Vihman (2007), children acquire phonology in a word-based way: phonological units smaller than the word are defined in terms of their phonotactic roles within the word, and the starting point of phonological acquisition is "an inductive generalisation based on the child's first repertoire of phonetic patterns and their interaction with the phonological structure implicit in the ambient language that the child is attempting to reproduce" (Croft & Vihman 2007: 708; see also Velleman & Vihman 2002, Vihman & Velleman 2000). However, phoneme-level segmentation in English-speaking contexts, especially for phonemes which happen not to coincide with a syllable onset or rime, usually begins to take place at the same time as the onset of literacy instruction. This is unlikely to be a coincidence. Learning to read and write in an alphabetic orthography means that children have to reshape their analyses of the sounds of words so as to match the analysis conveyed or implied in a word's conventional spelling. An investigation by Treiman (1997) of the spellings produced by English-speaking children in the beginning stages of learning to read and write suggested that children's departures from a word's conventional spelling are not merely naive errors, but are based on acoustically very plausible analyses of the sounds in those words (e.g. indicating an affricate analysis for the sound at the start of *dry*, a rhotacised vowel at the end of *her*, etc). She argues that it is in the process of literacy acquisition that children are led to bring their analyses of word-sounds into line with those embodied in conventional spellings:

> "As children see that this sound [at the start of the word dry, e.g.] is always spelled with 'd', their classifications change. … Orthography, originally learned as a representation of speech, takes on a life of its own and begins to influence children's views about the language itself" (Treiman 1997: 200; see also Olson 2002a, Ong 1992).

In this way her analysis suggests that a person's idea of spoken language is something that is shaped by the process of becoming literate.

The difference that literacy makes to language can be seen not just in pre-readers, but also in adults who are non-literate, or who are literate in a non-alphabetic script. In a now classic study, Morais et al (1979) administered phoneme deletion and phoneme addition tasks to non-literate adults in Portugal, and found that they had great difficulty performing the tasks, compared to a control group of literate adults. Although this study has been critiqued from a variety of angles (e.g. Goswami and Byrant 1990), subsequent studies extended the findings of the Portuguese study by comparing the performance of adults who were literate in different kinds of orthographies. Read et al (1986) compared two groups of Chinese adults, one in which participants were literate in the traditional syllable or morpheme based script, and one which participants were also literate in the alphabetic pinyin script, and they found that the participants were able to carry out phoneme manipulation tasks only if they were alphabetically literate. These findings were corroborated by Prakash et al (1993) in studies with participants who were literate in Kannada, which is semi-alphabetic, and those who were also literate in English; they found that only those who had alphabetic knowledge performed well in phoneme segmentation tasks. Literacy experience has a significant influence on people's language knowledge and in particular on the ways they choose to divide up the speech stream.[6]

The filtering of spoken language through the conventions learned for written language can be also seen in literate societies in a variety of everyday ways. Derwing (1992) gives a number of instances of orthographic knowledge influencing people's perception of the sounds of words, including the finding that people think there are more sounds in the word *pitch* than in the word *rich* (Ehri & Wilce 1986) – since the rhymes of these words are identical in terms of sound, the belief that one 'has more sounds' than the other can only come from the way they are spelled. Treiman and Danis (1988) also found that intervocalic consonants are only perceived to be ambisyllabic if they are geminate in orthography. Derwing (1992) presents data relating to phoneme deletion skills in fully literate adults when they are presented with words which do not have a one-to-one mapping of phonemes to letters – if people are asked to delete the "b" from *basket*, they find it much easier than if they are asked to take the "k" out of *taxi*. Similar effects have been found in

[6] These findings should of course not be taken to suggest that people or societies which are not familiar with alphabetic or other writing systems are lacking in the ability to identify small sound differences (neither the ability to come to identify them once they are pointed out, nor the ability to use them implicitly). In non-alphabetically literate societies this can be seen for example in the way that syllabaries are systematised according to initial consonant (eg ka, ko, ki, etc), and vowel pointing or the system of *matres lectiones* in scripts such as Hebrew which generally only represent consonants could also be taken to show that detailed word-internal analyses can be carried out in the context of writing systems which do not depend on them. Elbro (2002: 22-23) further provides an example of Icelandic poetry from the 10th century, when he argues the society would have been mainly illiterate, and which illustrates "advanced poetic devices," including alliteration based on the first consonant of a cluster (*sandr*, *svalar*). But as Scholes (1993) points out, whatever capacity or potential there is among non-literate individuals for analysing speech in a segmental or other detailed way, "spoken communication does not provide a data base sufficient to the employment of this capacity" (Scholes 1993: 91; see also Olson 1994). This position is also elaborated by Harris (2000): "No one argues that, prior to the advent of writing, speakers were quite oblivious to features of oral language. That would be like supposing that musicians were tone deaf before the invention of musical scores. It is clear from the evidence of poetry in pre-literate cultures that awareness of quite subtle patterns of rhythm, rhyme and assonance did not escape either the pre-literate poet or the pre-literate audience. What is at issue, however, is the role of writing vis-à-vis speech in that symbiotic relationship which characterises literate societies" (2000: 210-211).

many other studies, such as Ziegler and Ferrand's (1998) French auditory lexical decision study, which showed that when rhyming words whose rhymes are spelled differently (for example, French *plomb* 'lead' and *prompt* 'prompt', both with [ɔ̃]) are presented to native adult listeners the response time is longer than for pairs of words such as French *stage* 'training course' and *rage* 'rage' whose rhyme [aʒ] shares the same spelling. Treiman and Cassar (1997) found that both beginning readers aged 6 and university students were more likely to report that vowels contained a single 'sound' if they were the name of a letter (e.g. even the diphthongal vowel /ai/, due to its being the name of the letter <i>), and Treiman and Cassar comment that "neither children reading at the beginning first-grade level nor college students can completely divorce sound and spelling and think about the former independently of the latter" (1997: 777). As Shankweiler and Fowler (2004) put it, literate adults "find it easier to call to mind a word's spelling than its phonemic elements, thereby unwittingly substituting knowledge of spelling for knowledge of phonemic structure … It seems that once literacy is well established, some adults are no longer able to break up spoken words into their phonemic parts" (2004: 491).

Findings such as these bear out the validity of the proposal which was put forward by Ehri (1992), that as soon as connections are made between sounds and spellings, "spellings become amalgamated to pronunciations and are retained in memory as orthographic 'images' of the words, that is, visual letter-analysed representations … [which] also become amalgamated to meanings in memory" (1992: 120). The concept of an amalgam such as this would seem to provide an explanation for why readers find it so difficult to break up words into 'phonemic' parts when the spelling is mismatched with the phonemic transcription. Suggestions such as this, however, seriously undermine the prevailing belief in the separateness of spoken and written language, and of the independence of the units identified as phonological structural units from written text in general and alphabetic orthography in particular. Back in the 1930s JR Firth commented in the context of a similar controversy, "In the end we may have to say that a set of phonemes is a set of letters. If the forms of a language are unambiguously symbolised by a notation scheme of letters and other written signs, then the word 'phoneme' may be used to describe a constituent letter-unit of such a notation scheme" (Firth 1957 [1935]: 21). As Uppstad and Tønnessen (2007) point out, the acceptance of a view such as Ehri's is rather subversive of the prevailing worldview which regards the units which are posited to participate in phonological structures and processes as being independent of literacy, even though it is not regarded as a particularly radical divergence from the mainstream.

1.3.2.2 The causal claims of the Phonological Deficit Hypothesis

All of this foregoing discussion has a bearing on the Phonological Deficit Hypothesis in some very fundamental ways. Particularly, it highlights a serious problem with the hypothesis in relation to the direction of causation which it stipulates: a deficit in phonological representations is said to cause deficits in many other cognitive skills and tasks as well as literacy.

The danger of tautology

This position can be seen as problematic primarily because, if it is the case that phonemically segmented representations (and phonemic phonological awareness) are both at least influenced, if not determined, by familiarity with an alphabetic orthography, then the Phonological Deficit Hypothesis is brought into serious danger of tautology, due to its claim that a phonological representations deficit causes the difficulty with mastering alphabetic literacy. Proponents of the Phonological Deficit Hypothesis are not unaware that the tautology criticism has been levelled against it and they do reject it, but they do so with little in the way of tightly argued reasons in support of this rejection. For instance, the problem of the tautology is mentioned in Ramus (2003), but rejected specifically on the grounds that, in addition to the phoneme awareness deficit, dyslexics have other phonology-related deficits too:

> "it is sometimes argued that the phonological theory is a tautology rather than an explanation, that phonology and reading are two sides of the same coin, in the sense that phoneme awareness is enhanced by reading skill as well as the other way around. This point might be valid if the phonological deficit could be reduced to a problem with phoneme awareness; however, this is not the case. Indeed, beyond phonological awareness, dyslexics have at least two other major phonological problems, in rapid naming (of pictures, colours, digits or letters) and verbal short-term memory, neither of which can be said to rely on reading" (Ramus 2003: 215).

However, this argument does not contribute to the question of whether phoneme awareness itself is dependent on alphabeticism (and as we shall see below, the connection between phonological representations and the other tasks mentioned here can itself be called in question). Similarly, although the possibility that the phonological deficits "may be a consequence as much as a cause of their failure to learn to read," is mentioned in Snowling (2001) and Gallagher et al (2000), it is again dismissed, this time with an argument drawn from observation of children at risk of dyslexia. In a review of Scarborough's (1990) longitudinal study of at-risk children from 2 to 7 years, Snowling (2001) points out that children who go on to develop dyslexia differ in their early language skills, with dyslexic children having more limited syntax and making more speech errors than the non-dyslexics from the age of 2;6 onwards. These results are interpreted as being "compatible with the Phonological Deficit Hypothesis" (Snowling 2001: 43), and the only concern which is identified for the Phonological Deficit Hypothesis is that the phonological problems were manifested in the context of problems with other areas of spoken language too: the existence of spoken language-related deficits prior to literacy instruction is presented as an argument that there is no tautology. Again, however, this does not address the central problem: demonstrating that spoken language skills in general are impaired prior to the onset of literacy instruction is not the same as demonstrating that the language skills which are necessary specifically for literacy acquisition exist either prior to literacy instruction or independent of literacy experience.

It is also worth noting in relation to the causal claims of the Phonological Deficit Hypothesis that even if phonology did "cause" something relevant, it is still necessary to explain what caused the phonology itself to turn out that way. It is important to recognise that phonological representations are not themselves immune from external influences: phonological representations do not simply unfold as a matter of course in the child acquiring spoken language, but are themselves subject to influences from contingent factors. One such factor is the size of the child's vocabulary, as is argued by Vihman and Croft (2007): the child's growing vocabulary creates one of the key language-internal pressures to organise the phonological representations of their learned words in terms of increasingly smaller units (see also Storkel 2002, Storkel & Morisette 2002). Usage-based models (e.g. Bybee 2001) prioritise details of how particular linguistic forms are used in the description of what a speaker 'knows' about the sounds of language, viewing phonological representations as a result of a complex set of cognitive skills and processes interacting with each other and the environment throughout the process of development. From a slightly different perspective, it has been argued that the process of phonological acquisition is more or less equivalent to the process of acquiring the sociophonetic variation patterns which characterise the child's ambient language (Kerswill & Shockey 2007), making phonological knowledge and phonological acquisition almost entirely dependent on the socially relevant input which the child receives (Docherty & Foulkes 2000, Foulkes & Docherty 2006). If phonological representations are indeed therefore so contingent and malleable, it is implausible that they could cause deficits in a skill such as nonword repetition (for one example), as if it was more basic than, or equally basic as, working memory as a cognitive skill. Even with a more obviously language-related skill such as vocabulary, if phonological representations are even to some extent dependent on vocabulary, then it is too simplistic to say that deficits in naming skills can be explained by deficits in phonological representations, as if there was one single direction of causality in the relationship between phonology and the lexicon.

As was argued above, some particularly significant influences on the mind and mental representations include those which are brought to bear in the process of literacy acquisition (although, again, many other even language-internal pressures can be brought to bear on the developing phonological system (Storkel & Morisette 2002)), but on an even more concrete level, it is clear that cognitive skills and processes must be supported or 'underwritten' by physical processes at some point. Goswami (2006), for instance, points out that even if phonological representations are accepted as comprising the core cognitive deficit in dyslexia, "this cognitive deficit presumably has antecedents" (p257); "the research field has yet to find a cognitive deficit that arises detached from any neural underpinnings in terms of sensory or perceptual problems" (p259). Goswami is of course making this point with a view to arguing in favour of a particular sensorimotor or perceptual theory, but her comments also support the point I am making here, that even plausible cognitive explanations cannot be the end of the story. It is not sufficient as an explanation to say that abstract mental representations are impaired, because the mental representations have to come from somewhere – and without speculating as to what the precise neural underpinnings or perceptual antecedents could be, it remains the case that mental representations, to the extent that they exist, are shaped and moulded *so that* they take up their eventual shape.

The alphabetic principle in reading acquisition

In this context it is useful to consider the concept of grapheme-to-phoneme correspondences, and how a role for metalinguistic skills has been identified in the process of literacy acquisition. The gist of my argument so far has been in effect that literacy itself provides the ideal metalanguage: the phonological segments which literate speakers seem to operate with are more or less entirely derived from their familiarity with their writing system. This position does however stand in contrast to at least some formulations of the alphabetic principle, and the concept of acquiring grapheme-to-phoneme correspondences.

There is a sense in which it is true that, as Olson (2002) paraphrases the position of Isabelle and Alvin Liberman in relation to the alphabetic principle,

> "in learning to read, one must make a completely new analysis of the sound patterns of speech. This analysis is quite different from that required for ordinary oral production and perception. In learning to read, one must learn to hear, i.e. analyse, speech in a new way, namely into categories that map on to the specific properties of the written code" (2002: 30).

Units of written text have sound values conventionally attached to them, and it is important for beginning readers to make associations between the letters and the sound values. However, there are two pitfalls which should be avoided in discussions of the relation between speech and text. One is to think that spoken words consist of phonemes; the other is to think that children's implicit knowledge of the sounds of language is phonemically organised prior to their interaction with alphabetic orthography.

The first of these notions is expressed by, for instance, Vellutino et al (2004: 5), when they state that "spoken words consist of individual speech sounds (phonemes)." It is echoed by Hulme, Snowling, Caravolas and Carroll (2005), who define the alphabetic principle as "the idea that individual letters or letter clusters – graphemes – represent the sounds – phonemes – of spoken words" (2005: 353). But such a view as this represents a serious divergence from how 'phonemes' are understood by phonologists, and it should not be overlooked either on the grounds that it is made widely, by respected writers and researchers, or on the grounds that the difficulties surrounding it are not immediately obvious. Although letters (or groups of letters) can represent (some aspects of) the sounds of language, to say that they represent the phonemes of spoken words embodies a fundamental misunderstanding both of the nature of spoken language and of the concept of the phoneme. Spoken language does not consist of phonemes: segments including phonemes are known not to be identifiable on the basis of the speech stream itself, and it is a well documented fact that the concept of physically invariant slices of the speech stream is empirically untenable. The notion of a phoneme has always crucially involved the notion of abstraction, to some degree or another – phonemes are abstract units which need to be inferred from speech, as they are not there directly.[7]

Furthermore, even the inferred, abstract, phonemic segment is an inadequate way of representing what is acknowledged on all hands to be an inherently continuous, nonsegmented flow of acoustic information. This was recognised in the 1880s by the Neogrammarian Hermann Paul, who spoke of a word as "essentially a continuous series of infinitely numerous sounds" (cited by Harris (1986: 114)), a comment which Harris develops by pointing out,

> "there is no question of using a separate symbol for each sound, because sounds are not discrete segmental units. Or if they are, there must be an infinite number of them in even the 'shortest' spoken word: for the same reason that there is an infinite number of sequential divisions in an inch. The so-called 'alphabetic principle' consequently enshrines a fundamental misconception about the nature of sound."

The other caution which must attach to any discussion of the acquisition of the grapheme-phoneme principle is the need to avoid the suggestion that while graphemes need to be learnt, phonemes are already available to the learner as entities which must only be matched to the graphemes visible on the page. As was

[7] Even when the phoneme was given a fundamental role in phonological theory and description (up until perhaps the 1980s), it was key to the whole notion of the phoneme that it was an abstract unit, not directly perceivable in any way. The most concrete it seems to have been was when the British school under Daniel Jones viewed a phoneme as a collection of similar-sounding phones, although even then, it was not phonemes themselves which were thought to occur in the speech stream, but instantiations of phonemes in the form of one of the members of that class of sounds. In any case, at least as far as the overwhelming mainstream of phonology is concerned, this understanding of phonemes fell by the wayside as time went on – the notion of a phoneme came to be located firmly in the context of oppositions and contrasts and relations within a language system, leading Twaddell (1935) to make the startling but accurate observation that "a phoneme, accordingly, does not *occur*; it 'exists' in the somewhat peculiar sense of existence that a brother, qua brother, 'exists' – as a term of a relation" (1935: 49, my italics).

argued above on the question of what segments speakers can be said to have (§1.3.2.1), having a phonemically organised knowledge of the sounds of language is inextricably intertwined with being alphabetically literate, which suggests that in reading acquisition, it is both graphemes and phonemes which have to be acquired, not just graphemes. Although this should of course not be taken to undermine the importance of learning the relationships between individual letters and their canonical sound values – as Castles and Coltheart (2004: 82) point out, "knowledge about letter-sound correspondences is a primary building block to reading" – yet, as has been argued, it is only in the process of seeing how written words match with spoken words that implicit knowledge of spoken language takes on as phonemic an organisation as the conventional orthography will allow.

What I would like to highlight, therefore (in advance of the discussion in §1.3.3), is the importance of the role of metalinguistic skills in reading development. The skills involved in setting up grapheme-phoneme correspondences and acquiring the alphabetic principle – which can be glossed as the skills involved in learning to match letters (or letter clusters) with their canonical sound values, and aligning the canonical sound values with their counterparts in connected speech – themselves imply a shift of perspective on behalf of the learner away from communicating or understanding the content of a spoken message to conceptualising the speech signal itself as having the particular properties indicated by the written text conventions they are acquiring. This is what I will refer to in §1.3.3 as the requirement for a focus on the *form* of spoken language – that aspect of the reading acquisition process in which learners must not only acquire an understanding of the properties of written text but also analyse speech in the terms provided by the properties of these written texts. Whatever can be said about (phonological) mental representations once this metalinguistic analysis has been conducted, I would like to argue, should be given a rather more secondary position than the metalinguistic analysis itself in the context of understanding how reading activities are performed and the cognitive aspects of literacy impairment.

Summary

Literacy experience therefore needs to be recognised as something which has a significant influence on people's language knowledge – and even if the force of this point is somewhat more academic in the context of unimpaired language users in literate societies, it takes on a great significance and urgency in the context of understanding literacy impairments in a linguistically responsible way. Specifically, by assigning too much importance to the influence of language acquisition on literacy acquisition, we run the risk of overlooking the possibility that there is a two-way influence between language skills and literacy skills, such that people's language knowledge and acquisition are influenced by the literacy conventions which their society uses and which they themselves acquire. If phonological knowledge is even partly the result of becoming literate in a given orthography, then deficits in phonological knowledge may be at least partly the result of lack of success becoming literate, rather than the other way round. On this view, although segmentedness is undoubtedly a property of the phonological representations of unimpaired speakers of English, it is neither the result of information conveyed in the speech stream, nor the operation of innate mental preferences – rather, it is the result of pressures external to speech and spoken language – it arises through the speaker using the knowledge which they have as members of a literate society in order to analyse or reanalyse speech to make it fit the categories required by the conventions of their written language.

1.3.3 Evidence for a representations deficit

A second aspect of the Phonological Deficit Hypothesis which I would like to analyse here relates to the issue of metalinguistic skills, and the extent to which tasks that tap into different kinds of metalinguistic skills can be said to be informative about implicit mental representations of spoken language. Although the Phonological Deficit Hypothesis relies on a view of phonology which assumes abstract symbolic mental representations which constitute a speaker's implicit knowledge, there is not a great deal of material in the kinds of evidence which is brought forward in support of the hypothesis which has a direct bearing on implicit and abstract knowledge.

In spite of the insistence with which a representations deficit is named in the Phonological Deficit Hypothesis, the body of evidence which is cited in favour of a phonological representations deficit does not in fact speak as clearly to the question of the nature of dyslexics' phonological representations as seems to have been generally assumed.

It may be recalled that in the review of the evidence cited in favour of a phonological representations deficit in dyslexia above (§1.2.1), the body of data was grouped under three broad classifications – categorical perception tasks, phonological awareness tasks, and tasks which involved other additional cognitive skills – all of which called on phonological representations to *some* extent, but none directly. For instance, in relation to categorical perception, it is acknowledged by all parties that a categorical perception deficit does not seem to be a characteristic of all individuals with dyslexia, and the weight of this evidence is accordingly downplayed by proponents of the phonological representations hypothesis. Although the available studies to date suggest that it is indeed appropriate to play down the weight of this evidence, what this means in effect is that the phonological representations hypothesis is deprived of one of its most promising sources of evidence. That is to say, although it is difficult to put any kind of quantification on abstract mental constructs like phonological contrasts, categorical perception tasks are one of the best ways of approaching this problem that have been reported in the dyslexia literature so far. Although categorical perception tasks do involve some level of metalinguistic analysis – they require focusing on the auditory properties of words in order to undertake the task rather than using the auditory properties of the words as guides to intended meaning – yet evidence of a categorical perception deficit would be to some extent indicative of inadequate *implicit categorisation* of speech sounds, which would in turn constitute highly suggestive evidence of a deficit in *representations as such*. However, since this evidence is not forthcoming, and because the hypothesis's own proponents accept that that is the case, they are forced to rely instead either on phonological awareness tasks (§1.2.1.2) or else on tasks such as nonword repetition or rapid automatised naming (§1.2.1.3), to provide evidence of the claimed specific phonological *representations* deficit.

However, it can be seen that there is a fairly substantial problem with using phonological *awareness* tasks as a source of evidence about phonological representations, in that these tasks are by definition somewhat remote from *representations* as such: phonological representations are a different kind of knowledge from what is known via metaphonological analysis. This is understood to be almost axiomatic within phonology as an academic discipline: what phonologists study tends to be seen as consisting mainly of those aspects of the patterns of speech which are subconscious, or only implicitly known to speakers of the language in question (as well as linguistically relevant, rather than either merely phonetic or physical). Implicit knowledge is what is assumed to enable communication – in everyday conversation, speakers implement and draw on their implicit knowledge for the purposes of talking and listening to each other in a meaningful way, and successful communication is assumed to rely on speakers' implicit knowledge of the sounds of language and their ability to draw on it with a great deal of automaticity in order for spoken interactions to be meaningful: phonological knowledge itself may remain implicit for many speakers for most of the time, as speakers engage in talking and listening for meaningful reasons – to convey or take in indexical, social, affective, and propositional kinds of information. This can be exemplified in phenomena such as coarticulation, vowel reduction in connected speech, allophonic variants such as the aspiration of voiceless stops in

English, the correlation of vowel height or backness with sociolinguistic factors, and so on – all of which are essential for fluent communication, and none of which are necessarily available to introspection by speakers in the course of spoken interactions or on reflection on their own or others' productions. Theoretical accounts of this implicit knowledge (what it consists of, how it is organised, and so on) are built on analysts' inspection of the forms which speakers use, but the phonological knowledge which phonologists ascribe to language users need not be at all recognisable to the language user as a good description of what they know.

Of course, there are situations when speakers may well bring their implicit knowledge to conscious inspection – that is, when they may engage in metalinguistic or metaphonological analysis of the *form* of their own productions or the productions of other speakers they hear (rather than the content or *meaning* of these spoken productions). Situations where it becomes important to be aware of the form of words rather than their meaning might include, for example, in language games, punning, rhymes and alliteration; in identifying the source of mishearings; speaking or listening to someone with an unfamiliar accent, and so on. But it should be noted that although most of these situations are fairly common in everyday language use and some of them can serve important sociocultural purposes, they do not constitute the primary data from which theories of the acquisition or impairment of phonological knowledge are constructed. Speakers' metalinguistic reflection on language is not a good guide to their actual linguistic behaviour or whatever implicit 'mental representations' of language they might have. Phonological awareness tasks draw on other (and/or more) skills besides the application of implicit phonological skills, and conscious introspection of otherwise implicit knowledge or behaviour is highly susceptible to external influences which have the effect of obscuring what that knowledge consists of and how it operates when no such inspection is being applied. This is argued by Silverman (2006), among others:

> "Some linguists argue that our ability to consciously manipulate speech sounds on demand opens a window onto the genuine structural properties of linguistic sound systems. That is, our intuitions about speech sounds, and our ability to consciously manipulate these speech sounds, provide evidence of these sounds' status as linguistically significant phonological entities. But just as our feelings about language are extremely unreliable with respect to offering insight into linguistic sound structure, our ability to consciously manipulate speech sounds provides us with no insight whatsoever about linguistic sound structure. When we play with our language, there is no reason to assume that the elements we are manipulating are the genuine building blocks of the sound system." Silverman (2006: 10-11; italics original)

It has also been argued, for instance by Zwicky and Pullum (1987), that language games (such as schoolchildren's spontaneous forms of pig Latin) are a 'special' use of language, and not sufficiently similar to ordinary linguistic processes to license making use of them as data with a bearing on underlying language structures. Although they make this point primarily with morphology in mind, it applies to phonology too.[8] So, while language users' reports of introspection can be useful in some contexts, as Pierrehumbert, Beckman, and Ladd (2000) point out, ultimately such reports are "opinions. They are high-level meta linguistic performances that are highly malleable. They do not represent any kind of direct tap into competence, but are rather prone to many types of artefacts, such as social expectations, experimenter bias, response bias, and undersampling" (2000: 189-190).

Metalinguistic skills, therefore, demand something more than the ability to communicate effectively using spoken language. Metalinguistic analysis or awareness demands that, rather than making use of language as a means to a communicative end, the speaker must treat language as an end, or at least an object of investigation, in its own right. This can be expressed informally as the difference between 'just using' language and 'thinking about' language: metalinguistic analysis demands the adoption of a reflective viewpoint on language which is not necessary

[8] It is interesting that whereas Zwicky and Pullum (1987) treat Pig Latin as a means of gaining insights into morphology, it is typically used in the dyslexia literature as a tool for investigating phonology. This perhaps bears out Zwicky and Pullum's point.

for efficient and fluent verbal communication. As Tunmer and Herriman (1984) put it,

> "metalinguistic awareness may be defined as the ability to reflect upon and manipulate the structural features of spoken language, treating language itself as an object of thought, as opposed to simply using the language system to comprehend and produce sentences. To be metalinguistically aware is to begin to appreciate that the stream of speech, beginning with the acoustic signal and ending with the speaker's intended meaning, can be looked at with the mind's eye and taken apart" (1984: 12).

Hjelmquist (2002) further points out that this is a form of decontextualisation, in that language needs to be considered apart from its use in meaningful contexts:

> "attention is also deliberately focused on the form of cultural knowledge, not just on the contents conveyed. This type of representation system is no longer dependent on, or possible to learn, through everyday experiences of the 'natural' world. Abstraction from everyday experience – decontextualisation – becomes the keyword rather than dependence on such experience" (2002: 11).

It is indeed widely agreed that some kind of metalinguistic analysis is required to be undertaken on the forms of spoken language in order for beginning readers to bring their implicit knowledge of spoken language into line with the conventions of written language (whether the ability to undertake this metalinguistic analysis is seen as a prerequisite to (Tunmer & Bowey 1984) or a consequence of (Scholes & Willis 1991) engaging with written text). In fact, in the experiments reported in the following chapters, I will go on to test the hypothesis that it is indeed a deficit in metalinguistic analysis, rather than putative deficits in mental representations, which should take priority in any cognitive account of dyslexia. This view of reading acquisition, and specifically this view of what is involved in metalinguistic analysis, diverges somewhat from the model of reading acquisition assumed in the Phonological Deficit Hypothesis (as advanced by Snowling (2000), e.g.). The Phonological Deficit Hypothesis assumes some version of a dual-route model of reading, in which, in addition to a 'direct' or lexical route from word to pronunciation, a non-lexical or sub-lexical route is posited whereby the reader arrives at the pronunciation of a word on a grapheme-by-grapheme basis. The reading acquisition model which is posited therefore locates a role for metalinguistic analysis at the stage of acquisition where the learner sets up grapheme-to-phoneme correspondences (or acquires the alphabetic principle). As was argued previously (§1.3.2.2) this can only be a viable description of reading acquisition if it is granted both that phonemes are the products of linguistic analysis rather than inherently present or recoverable from the speech stream, and that the learner must acquire both graphemes and phonemes in the process of learning to read. Further, however, whereas the metalinguistic analysis referred to in the context of setting up the nonlexical route involves introspection of already existing mental representations (it "taps the organisation of the phonological system" (Snowling 2000: 54)), I follow the position outlined by, for instance, Hjelmquist (2002), Olson (2002a), and Ong (1992) in construing the metalinguistic analysis required by and for reading as one kind of decontextualisation, and one in which the learner uses his or her newly acquired understandings of the properties of written language as an interpretative grid to impose on the spoken language he or she hears and produces: "it is not reflective awareness in general that is at play, so much as the reflective analysis of speech into the categories mandated by the script" (Olson 2002b: 30). This perspective makes contact with psycholinguistic models of reading at the point where they invoke grapheme-phoneme correspondences, yet the understanding of what is involved in metalinguistic analysis itself is rather different in both cases.

It may, additionally, be useful to distinguish different kinds of metalinguistic analysis from each other. The kind of metalinguistic analysis which speakers are invited to engage in by situations such as those outlined a couple of paragraphs ago is not necessarily the same kind of metalinguistic analysis which is important in studies of children's 'phonological awareness'. In the section on the phonological awareness tasks which have been used in studies of dyslexia (§1.2.1.2), it was mentioned that it is possible to distinguish the various tasks which are commonly grouped together under this label depending on how 'challenging' they were – a metalinguistic analysis which simply identifies putative phonological units, as is done in counting and odd-one-out tasks and tasks such as rhyme or alliteration judgment, can be viewed as much less challenging than metalinguistic analyses which are undertaken for the purpose of moving, changing, substituting, or otherwise modifying a particular putative phonological unit.

It is perhaps the 'less challenging' of these tasks which have more in common with the process of learning to read itself. The kind of metalinguistic analysis which beginning readers must undertake on the forms of spoken language is a process which is itself more analogous to the task of identifying units within words, than the 'more challenging' task of isolating the units and carrying out some further operation such as deleting or substituting them, although being able to do the former is a skill which can then be built on so as to undertake the latter. The ability to treat the forms of spoken language as an object of interest in its own right, with a view to construing it as consisting of orthographically relevant units so as to relate these units to written text, is what is identified as integral to successful reading both by scholars who see it as a prerequisite to and by those who see it as a consequence of engaging with written text.

However, this 'basic' kind of metalinguistic analysis is different from the ability to delete, substitute, or move a unit which is isolated within a word. Although this ability clearly also demands attention to the form of the word, and an analysis of the word which converges on the same segmentation as is expected in view of the word's conventional phonemic or orthographic segmentation, in addition to this basic metalinguistic analysis it also demands a total isolation of the segment involved from its environment, to make it absolutely decontextualised and able to be extracted and moved or replaced subject to no limitations other than what are suggested by phonotactic or orthographic considerations. Whereas basic metalinguistic analysis can be considered as artificial relative to spoken language although presumably useful in terms of learning to read, the kind of 'unit manipulation' which is involved in tasks such as phoneme or syllable deletion is artificial with respect both to spoken language and to the metalinguistic analysis which is assumed to be required for reading. The extra artificiality and the extra cognitive demands which characterise phonological manipulation tasks, therefore, seem to imply that it may be useful to distinguish between them and more basic metalinguistic tasks, as will be seen later (§1.5).

The implicit knowledge which a speaker can draw on in order to achieve communicative goals should therefore be recognised as a different kind of knowledge from the product of the speaker's analysis of the form of language: theories about *representations* should therefore be carefully distinguished from studies of speakers' *metalinguistic* abilities. While phonological awareness is one *possible* source of data about phonological representations, it is far from a direct source and therefore far from ideal, and the reliance on the results of phonological awareness tasks in the Phonological Deficit Hypothesis greatly weakens its claim to be speaking to phonological representations as such. In fact, it makes it virtually impossible to say whether 'phonological awareness' is the skill which is ultimately responsible for the phonology-related deficit in dyslexia, rather than phonological representations.

To move towards concluding the present section, a brief comment is required on the connection between phonological representations and the tasks in the third category of evidence highlighted in §1.2.1.3 above – nonword repetition, rapid naming tasks, and so on. The evidence which these tasks can contribute is again somewhat weak, as can be seen by considering the extra skills that are demanded by the various tasks included in this category. In nonword repetition it is short term memory which has been understood as the key skill of relevance, with phonology playing a much more secondary role (Gathercole et al 1994), and nonword repetition also includes a role for vocabulary size, and potentially also motor articulatory skills. In addition, naming tasks rely on vocabulary size, which is related to reading experience; rapid naming tasks also demand speed, as Wolf et al (2000) have argued; and so on. None of the tasks in this third category is a 'pure' test of phonological representations, and although they are sure to involve phonological skills to some extent, they cannot be assigned any sort of critical status or weight in speaking to the question of phonological representations. They are neither intended to be nor are they capable of being measures of phonology specifically, and nor do they (for that very reason) give particularly direct evidence about the nature of phonological representations.

In conclusion, it can be noted that the question of the strength of the evidence in favour of the Phonological Deficit Hypothesis has also been recently and independently addressed by Ramus and Szenkovits (2008). Having argued earlier (Ramus 2001) that due to lack of engagement with the contemporary phonological literature there was a large number of outstanding questions relating to the phonological aspect of the Phonological Deficit Hypothesis, the authors in this article review several studies which have recently been carried out into directly phonological phenomena in dyslexia. These studies include aspects of phonological similarity, the representation of foreign speech contrasts, the perception of voicing assimilations, and perceptual biases induced by language-specific phonotactic constraints (see references in Ramus & Szenkovits 2008). The results of all these studies uniformly show that whenever these phonological properties of the stimuli were manipulated, the performance of dyslexics and controls was equally affected, and the conclusion drawn from the results of these studies is that they "are compatible with the idea that their [i.e. dyslexics'] phonological representations and processes for lexical access are intact" (Ramus & Szenkovits 2008: 136). This review provides a valuable external source of support for the argument being made here, that the existing evidence which is currently used by proponents of the Phonological Deficit Hypothesis to argue for a *phonological representations* deficit in dyslexia is insufficient to make the case.

1.3.4 Suprasegmentals and reading

A final point which will be made as part of the present evaluation of the Phonological Deficit Hypothesis is that the role of suprasegmental phonology in dyslexia is arguably deserving of greater attention than it has currently received.

1.3.4.1 Prosody and written text

What has been said so far in relation to phonology (and the relationship between phonology and written text) has dealt with segmental phonology exclusively. Segmental phonology is the area which has historically had most attention given to it, whether the theoretical segment was conceived of as directly of fundamental importance (as in the phonemicist tradition) or more indirectly through the phonological *feature* which, in contemporary non-linear phonology, is taken as being more critical than the segment (Gussenhoven & Jacobs 1998) (although it should be noted that distinctive features are still *features of segments* – they are what define segments, and typically they are arranged hierarchically under a 'root node' which corresponds to the traditional notion of a segment (Clements & Hume 1995, Mielke & Hume 2006; see also Ladd 2006). However, for the last few decades, phonologists have been working more and more on the analysis of suprasegmental features too. The single most influential contemporary framework for doing so is autosegmental phonology, a model which sees phonological representations as consisting of several separate tiers of segments in formally specified ways (Goldsmith 1990, Ladd 1996). Suprasegmental phenomena can be identified fairly straightforwardly in principle, as phenomena whose domain of operation is larger than a single segment, and they can be listed as including, for example, syllable quantity or weight, stress, tone, intonation, and so on (Lehiste 1970).

In addition to the theoretical work on unimpaired adult suprasegmental phonology, acquisition studies have focused on a wide variety of suprasegmental phenomena. These include studies of intonation in infants by Snow (2006) in the 'British' tradition following Cruttenden (1997), and intonation in older children between the ages of 5 and 13 years by Wells, Peppé, and Goulandris (2004) in the 'American' tradition, following e.g. Ladd (1996). Lexical stress has also been investigated in 9 month old infants (Jusczyk, Cutler, & Redanz 1993), and it has frequently been observed that from around the age of 2 years typically developing children omit the weak initial syllables of words with weak-strong and weak-strong-weak stress patterns (such as *giraffe* and *banana*) (Gerken 1996), perhaps until the age of 4 years (Grunwell 1987) (see also Kehoe & Stoel-Gammon 1997). A third area of suprasegmental phonology is syllable structure, which has been investigated in depth for Dutch (see review and data presented by Levelt, Schiller, & Levelt (2000)). Syllable structure has also been implicated in a study by Harris, Watson, and Bates (1999) as the source of the impaired productions of a child with phonological disorder: what would otherwise have been regarded as an arbitrary series of divergences from the adult target vowel system can instead be insightfully analysed as a system which disallows branching nuclei (resulting in the shortening of long vowels relative to the adult system and producing sequences of a short vowel and stop instead of the adult diphthongs).

An initial observation which may be made as a preliminary to the discussion of suprasegmentals and reading is that few if any of these suprasegmental or prosodic features are directly reflected in text. The purpose of text in general is not to represent speech (see Harris (1986), especially §4), and this is particularly clear in English in the case of features such as lexical stress, rhythm, and voice quality, which have no orthographic counterparts at all, in spite of how indispensable they are in spoken language. In other cases, links between text and prosody may well exist, but only indirectly. For example, in Shattuck-Hufnagel and Turk's (1996) discussion of the relationships between syntax and prosody, the syntactic structures under consideration are mainly those of written text (rather than the syntax of spoken utterances), and in the discussion it is made clear that although there are some links between syntax and prosody, there are also important discrepancies. On the one hand, prosodic structure, as manifested acoustically through patterns of fundamental frequency, duration, amplitude, and so on, often does not reflect distinctions which are present in the syntactic structure (e.g. attachment ambiguities), and conversely it is not always possible to predict prosodic structure from the syntactic structure (e.g. the choice of whether pitch on an accented syllable is high or low is not determined by the morphosyntax). Shattuck-Hufnagel and Turk also show that constituents of a prosodic structure can sometimes 'violate' the corresponding syntactic structure, for example when a preposition is grouped into the same prosodic constituent as the preceding noun phrase, rather than with the following noun phrase, as a syntactic analysis would demand.

A similar indirectness can also be seen in the case of punctuation, which has a chiefly text-oriented purpose (rather than, for example, serving the purpose of marking phonological units in text, or of somehow making the writer's intended prosody recoverable by the reader). For example, although italics may sometimes be thought of as showing pieces of text which should be emphasised, this emphasis corresponds to intonation patterns only indirectly (if italics suggest intonation, they are only an occasional and incomplete indicator of what intonation might be appropriate). Moreover, italics have textual functions which are independent of their possible auditory renditions – they are far from redundant in texts which are never intended to be read aloud, for example, or in situations where no auditory distinction would be made even if the text was to be read aloud (such as when they identify the names of books or films). Nunberg (1990) in fact assigns italic font face to the same general category as word-initial capital letters, as kinds of graphical devices which serve the function of 'distinguishers' (among other things) – setting off one piece of text from its surroundings. The same principle applies to other forms of punctuation, such as exclamation marks and question marks: although sentences which end with these marks may perhaps be rendered with some kind of 'exclamative' or 'questioning' intonation patterns when or if the text is read aloud, their primary purpose is textual and typographic rather than spoken (Nunberg 1990). As Scholes and Willis (1990) put it, both "spelling and punctuation are, in their orthographic functions, quite independent of speech" (1990: 14; see also Bradley 1919).

In these examples and others, the key principle is that texts are for *reading*, not for *reading aloud*, and orthography and punctuation are literary devices for writers and readers, not primarily for speakers or public readers and hearers at all (Halliday 1985): written texts read aloud have different acoustic and articulatory properties compared to non-written speech being uttered in a communicative and interactive situation. The need which linguists have felt to develop special transcription systems for notating suprasegmental phenomena (eg ToBI (Tones and Break Indices); see Beckman, Hirschberg, & Shattuck-Hufnagel (2005)) bears further testimony to the fact that printed text does not serve the purpose of capturing prosodic features of speech – it is not what it is *for*, and it is not what it *does*. Although it would be inappropriate to see no relationship whatsoever between spoken and written language, it also should not be overlooked that the relation is indirect and that these two channels of linguistic communication have properties which are independent of each other and in some cases irrelevant to each other. Passages of written text, however punctuated, are neither a transcription of speech nor a series of cues for reading it aloud.

Against this background, however, there is a recent strand of research which has begun in the area of the relationship between suprasegmental skills and reading skills, or the role of prosody in reading. Some of this research was in fact brought together in a special issue of the *Journal of Research in Reading* (Volume 29, Issue 3, 2006), including three articles which I will discuss here as a means of throwing light on the significance of those aspects of phonology which are not represented in orthography, and the possibility of arriving at some principled position on the relation between broader phonological skills (i.e. also including those which are necessary for communication but not represented in written text) and literacy skills. Two of these papers (Wood (2006) and Whalley and Hansen (2006)) will be discussed immediately below, and the third (de Bree, Wijnen, and Zonneveld (2006)) will be discussed in §1.3.4.2.

The first of the three papers is Wood (2006), an article which argues that suprasegmental awareness can help to predict children's literacy development. In this article, the term 'suprasegmental awareness' can be taken as approximately equivalent to 'sensitivity to metrical stress,' and this sensitivity is measured by children's ability to identify the referent of a word which was deliberately mispronounced by manipulating its various metrical properties. In the experiment, 4 and 5 year old children listened to a mispronounced version of a bisyllabic word and had to select from a set of pictures which of the objects was intended. There were several different types of mispronunciation: in one condition, the word's metrical stress was reversed, which involved changing both the vowels in the word, including reducing one of the vowels to schwa, and changing the location of the word's lexical stress (eg 'sofa' /ˈsəufa/ becomes /səˈfa:/). In the other conditions, these three ingredients of metrical stress were manipulated individually: either by exchanging only the full vowel with an arbitrarily selected alternative (ˈsi:fə/), or by changing the lexical stress leaving the vowels intact (/səuˈfa:/), or by changing both the vowels so that both are unreduced (ˈsi:fa:).[9] It was found that the children's accuracy was lowest in the condition where words were mispronounced by changing their metrical stress, but that the 4-year old children, who were preschoolers, did not perform differently from the 5-year olds (who were in the reception year in a primary school in the English school system). This finding was

[9] When the reduced vowel in the original word is made into a full vowel, it appears that the choice was always to select the unreduced counterpart of the orthographic vowel, hence /a/ in *sofa*, /e/ (sic, for /ɛ/?) in *garden*, etc.

taken to show that, unlike 'phonological awareness' in the conventional sense, as tested by rhyme judgment (and nonword reading), this 'suprasegmental awareness,' namely the ability to correctly identify the referent of a suprasegmentally mispronounced word, is not affected by schooling or, by extension, the associated preliminary literacy instruction.

The claims which are made on the basis of these findings is that the mispronunciation task "assesses a suprasegmental awareness of speech sounds," and that this awareness "does not develop at the same rapid rate that segmental phonological awareness does in this age group ... it also seems less susceptible to influence from reading tuition" (Wood 2006: 283). Wood then answers in the affirmative the question, "Do these results suggest that suprasegmental awareness of speech might help to explain new variance in children's literacy development?" However, this cannot be an unqualified affirmative. It is one thing to think that suprasegmental awareness (in the sense in which it is analogous to conventional segmental phonological awareness) might explain new variance in literacy scores, but on closer inspection of what the tasks in this study involved, it does not appear that this particular study can support that claim. What the mispronunciation task unequivocally shows is that children with a greater flexibility in their ability to recognise atypical or unconventional pronunciations of words are better at phonological awareness and reading than others – but that is arguably much more of a general social-linguistic ability, not specifically suprasegmental at all, and not a question which relates to awareness itself directly or the relationship between suprasegmental awareness and literacy development.

A second study, Whalley and Hansen (2006), investigated the relation between prosodic skills and literacy development in a group of typically developing 9 year old children. Prosodic skills were tested by means of three different tasks targeting both phrase-level and word-level prosody. For phrase-level prosody, children were given an ABX task where they heard the name of a film, such as *Snow White*, then had to state whether it matched with the nonsense sequence "DEE-dee" or "dee-DEE". Word-level prosody was tested by means of compound nouns in two tasks – the receptive 'Chunking' subtask of the PEPS-C battery (Peppé & McCann 2003), where the children selected pictures to match either a list of three nouns (*chocolate, cake, and honey*) or a list of two (*chocolate-cake and honey*); and also a picture selection task where the children were required to differentiate between *high-chair* and *high chair*. Using multiple regression analyses Whalley and Hansen found that performance on the phrase-level tasks was most strongly related to measures of comprehension, and the word-level tasks were most strongly related to word identification scores (a nonspeech task (a same/different task with patterns of drumbeats) was found to contribute slightly but non-significantly).

A general comment which may be made on these two studies at this stage is that the finding that prosodic skill is in some way related to reading performance contributes to a bigger picture where good spoken language skills in general make for good written language skills. Muter and Snowling (1998) showed that as well as phoneme awareness (tested by phoneme deletion and rhyme judgment), a test of 'grammatical awareness' was also a good concurrent predictor of reading accuracy in children aged 9;9 ('grammatical awareness' was measured by a morphological test in which children provided the missing word from sentences such as 'Here is a man, here are two … (men);' 'The thief is stealing the jewels, these are the jewels that he … (stole)'). It was also shown by Muter, Hulme, Snowling, and Stevenson (2004) that for reading comprehension, 'grammatical skills' as tested by the same morphological task and vocabulary knowledge were significantly related to performance over and above phoneme awareness and letter knowledge. Scarborough (1990) also found that expressive measures such as mean length of utterance syntactic complexity at the age of 2 years were related to subsequent reading achievement when the children were 5 years old. As Gallagher, Frith, and Snowling (2000) point out, "literacy skill must depend not only upon the phonological skills the child brings to the task of learning to read, but also on their higher-level language abilities," where the phonological skills mentioned would seem to refer mainly to segmental or phonemic phonological skills. What holds spoken and written language together is that they are both communication (language), not that the one is a transcription of the other. Specifically with reference to suprasegmental phenomema, a recent study by Ashby and Clifton (2005) found that lexical stress patterns have an effect on eye movements during silent reading. They found that words such as *fundamental*, which have both a primary and a secondary stress (ˌfun.daˈmen.tal) took longer to read than words such as *preposterous* which has only a primary stress (preˈpos.te.rous) (all the stimuli consisted of 4-syllable words with either the wSww or the SwSw pattern). They argue that, "as stress information is not encoded in written English, the lexical stress effect suggests that participants supplied that phonological information during silent reading" (2005: B96). Of course, precisely because lexical stress is not indicated in English, this finding does not contradict the position of Nunberg (1990) and Halliday (1985) that the properties of written text are primarily textual in their nature and functions, rather than playing the role of indicating what the prosodic features of the text would be like if it was being read aloud, but findings such as these do contribute to what Whalley and Hansen call the "mounting evidence for a significant role for prosodic skills in reading development" (2006: 300). It may well be the case that beginning readers whose global language-related skills are good will be at an advantage to those whose linguistic skills are not so good. Once unimpaired children learn to read successfully they will be justified in expecting an orthographic representation for almost all meaningful differences between words, and because they are good at it, they are also justified in using orthography as a way of remembering words and building up analogies and contrasts so as to work out the meanings of the unknown words which they continue to be confronted with in print and speech. The habit of viewing language the written way will then become more dominant as a strategy than any early sensitivity to more spoken aspects of language – once literacy is acquired, written language takes priority over spoken language.

1.3.4.2 Suprasegmental representations in dyslexia

As we have seen, when the proponents of the Phonological Deficit Hypothesis make statements directly about phonological representations as such, the focus is only and consistently on (phonemic) segments, leaving something of a lacuna or gap in the theory. Of course, dyslexia is not generally thought of as involving a suprasegmental deficit – disorders of prosody are more typically associated with autism spectrum disorders (see, e.g., McCann & Peppé 2003). Yet the putative segmental deficit itself was not overt enough to be noticeable without the investigative work of researchers in the 1980s, and it is conceivable that an analogously subtle suprasegmental deficit might found to exist alongside it if the appropriate investigation was undertaken.

This point is particularly important given that the Phonological Deficit Hypothesis implicates 'phonological representations' in dyslexia in a very non-specific way – without restricting the claim to the representation of segments, for instance, even though in practice most attention is directed towards segmental areas of phonology. However, since phonological representations are assumed to be independent of orthography, one claim which would seem to be included in the Phonological Deficit Hypothesis is that a deficit in the various kinds of phonological processing tasks which have involved segments should also be apparent in other, non-segmental, areas of phonology. To put this in another way, given the dependence of the claim regarding representations on evidence relating to metalinguistic skills, one prediction which seems to be made implicitly by the Phonological Deficit Hypothesis is that whatever kinds of representations are impaired, the corresponding types of phonological unit should also be implicated in a metalinguistic deficit (if a segmental representations deficit is hypothesised on the basis of a segmental manipulation deficit, then a deficit in the manipulation of syllables, for instance, should also imply a deficit in the representations of syllables, and so on). Although this view stands in contrast to the argument made in §1.3.3 earlier, that implicit knowledge and metalinguistic awareness need not be related at all, it is nevertheless central to the claims of the Phonological Deficit Hypothesis that evidence should be sought which will allow the proponents of the hypothesis to ascertain even on its own terms whether the putative phonological deficit is restricted to segmental areas of phonology or whether it extends to suprasegmental areas too.

This point is in fact argued explicitly by de Bree et al (2006), the third of the studies in the *Journal of Research in Reading* special issue which was mentioned previously. This article is of particular value and relevance because its central argument coincides almost exactly with this point about the need for specificity in the Phonological Deficit Hypothesis with respect to suprasegmental areas of phonology. De Bree et al state that if the Phonological Deficit Hypothesis is correct, it can be expected that individuals with dyslexia would be impaired in suprasegmental phonology as well as segmental phonology – or in the terms of the present discussion, since the Phonological Deficit Hypothesis does not specify segmental phonology, it requires to be tested to see whether its prediction that the unqualified 'representations deficit' implicitly extends to suprasegmental areas too. De Bree et al investigated 49 Dutch children aged 3 years who were identified as being at risk of dyslexia on the basis of having at least one parent or sibling with a history of reading difficulties. They used a nonword repetition test in which the nonwords varied in terms of the number of syllables (2-4), the weight of the final syllable (light, heavy, superheavy, diphthong), and the position of stress (final, prefinal, antepenultimate, and pre-antepenultimate). The resulting items were classified as either regular, irregular, highly irregular, or prohibited, in terms of their stress pattern. It was found that repetition accuracy in both the at-risk children and the typically developing children decreased as the irregularity of the nonwords increased, but differences were seen between the groups when their error patterns were examined in detail: compared to the typically developing children, the at-risk children gave more monosyllabic and regularised responses, and whereas the children in the control group scored highly on both the 'regular' and 'irregular' nonword types, the at-risk children had high scores only in the 'regular' items. The authors comment however that both the group of children at risk for dyslexia and the control group had "essentially acquired the basic regularities of the Dutch stress system" (2006: 313). It would be useful therefore in the light of what has been argued in §1.3.3 to be able to distinguish the role of the regularity of the stress pattern from the role of the short-term memory demands in this task, but the authors do not comment on whether these patterns were seen equally frequently in both the shorter and the longer items.

The phonological skills which are necessary for spoken communication include the whole integrated complex of segmental and suprasegmental phenomena (at developmentally appropriate stages). But not all of phonology is represented in written text: writing out a single word, or syntactically cohesive strings of words, does little more than give suggestive hints at how they might sound in their spoken form in a conversational context. The three studies from the *Journal of Research in Reading* show that reading performance can be predicted not only by the ability to sound words out (on the 'phonemic' level), but also by more wide-ranging competence in sensitivity of one kind or another to a language's lexical stress patterns, even when the written language does not represent information about lexical stress in its orthography.

1.3.5 Questions relating to the phonological deficit in dyslexia

As an interim summary, it may be useful to name at this point the key areas of concern relating to the assumptions of the Phonological Representations Hypothesis which this thesis is particularly concerned with, ahead of the presentation of the research questions in §1.5. In brief, these key concerns are (i) the closely interconnected issues of segments and (ii) representations as distinct from metalinguistic skills, and also (iii) the issue of whether the 'phonological processing' deficit which has been observed in segmental areas of phonology also extends to suprasegmental areas of phonology.

(i) Especially in the context of impairments of literacy, the very close relationship between the symbols of alphabetic orthography and the units of segmental phonology demands a great deal of closer scrutiny. Since segments are at least tainted with, if not wholly derived from, alphabetic literacy, how can we be sure that segment-level findings about the phonology-related skills of individuals with dyslexia are informative about their phonology per se, rather than being a redundant or tautological restatement of their known literacy difficulties? This question shows the need to examine phonological representations independently of any input from literacy knowledge.

(ii) Relatedly there is the issue of metalinguistic skills. Although it is a robust finding that 'phonological awareness' is impaired in dyslexia, if the phonological representations of dyslexia are to be seriously investigated in their own right, more sensitivity is needed in relation to the convention of theoretical phonology that phonology is assumed and equipped to deal only with *implicit* representations, categorisations, and structures. This means that phonological representations need to be examined independently of any metalinguistic demands and in their own right.

(iii) Meanwhile, and somewhat separately, there is the issue of how far the hypothesised phonological deficit extends throughout the different areas of phonology in dyslexia. As we have seen, the Phonological Deficit Hypothesis is built largely on the evidence base of tasks such as phoneme counting and phoneme manipulation. By not investigating phonological phenomena other than the segment, this hypothesis leaves itself open to charges of ambiguity in the predictions it would make about suprasegmental phenomena in dyslexia. Taking advantage of the general way in which the hypothesis is formulated, for example, it might be inferred that dyslexics would be predicted to be impaired in suprasegmental phonology, simply because 'phonological representations' in general are implicated, without discriminating between different types of phonological representations – although equally, the unqualified implication of 'phonological representations' could be interpreted in a more narrow sense, as referring to segmental phonological representations alone. This means that we need to look beyond segments and into suprasegmental areas when testing the metaphonological skills of individuals with dyslexia in order to know how far the putative phonological deficit extends throughout an individual's phonological skills.

A practical suggestion for how the first two of these requirements can be met will be outlined in the following section, §1.4. The third issue will subsequently be addressed again in §1.5 below.

1.4 Phonology without orthography

1.4.1 Practical considerations

In practical terms, what is needed is some phenomenon in phonology which is independent of orthography, to serve as a testing ground for strictly phonological knowledge non-hybridised with knowledge of written language. Additionally, in order to constitute such a testing ground in the specific case of the phonological representations of individuals of dyslexia, not only does there need to be a phonological phenomenon which is not represented orthographically, but it must also be comparable with the kinds of phonological entities (units, representations, processes) which have already been investigated in individuals with dyslexia.

In English, such areas are harder to find (and operationalise) than might be expected, given the professed prioritising of spoken language over written language in linguistics in general and phonology in particular. Words, morphemes, and phonemes do not meet the first criterion as they are all familiar to people who write with alphabetic letters and can see the shape of words and put spaces between groups of letters, and therefore do not escape the orthography confound (Linell 1982; Scholes 1993). Meanwhile, aspects of phonology which are not represented orthographically include voice quality, intonation, and regional accent, but these phenomena tend to be viewed as phonetic, sociophonetic, and/or pragmatic phenomena rather than strictly phonological (although see Docherty & Foulkes 2000).

1.4.2 Escaping the confound with English compound vs phrasal stress

One phonological phenomenon which is directly comparable with what is currently known about segmental phonology, as well as being independent of orthography, is that of the stress difference which exists in English between compounds and phrases such as *toy factory* 'place where toys are manufactured' (compound) versus *toy factory* 'model factory for children to play with' (phrase).

This particular prosodic phenomenon has been recognized for decades as being analogous in suprasegmental terms with minimal pairs on the segmental level. This is how they were analysed by Daniel Jones (Jones 1967, chapter 26, especially §489), more recently by Ladd (1984), who discusses "the minimal pair *'steel warehouse* / *steel 'warehouse*" (p264), and more recently still by Vogel and Raimy (2002), who state specifically that "… stress may be used contrastively in a language to distinguish meanings, as phonemes do at the segmental level" (p227). As minimal pairs, these items and the others like them are a very close suprasegmental analogy of phoneme-based minimal pairs, which is exemplified for English in pairs such as *tea* versus *key*. Items such as "toy factory" and "steel warehouse" are always ambiguous in isolation in writing: it is impossible to tell whether it is the compound interpretation which is intended or the phrasal. In their spoken forms, however, the stress pattern is the guide to meaning.

In addition to items such as "toy factory", there is also a class of items which are not fully orthographically ambiguous, but which are similar to the "toy factory"-type items in that they rely on stress to distinguish them in isolation in spoken language. These are pairs such as *hotdog* versus *hot dog*, and *greenhouse* versus *green house*. The distinction between the pairs is of course made orthographically by the presence or absence of a space between the two components (although distinguishing them in this way may be optional). There are several controversies in the literature about how best to characterize pairs of items such as these (e.g. Giegerich 2004, 2006; Ladd 1984; Bauer 1998; Plag 2006). For example, Giegerich (2006) argues that stress is not a reliable diagnostic of compoundhood versus phrasality, because of cases such as *red herring*, *blue moon*, *white elephant*, and others like them, which have end-stress or so-called "phrasal stress", but which are nevertheless identified as compounds on the basis that they are not fully productive and not semantically transparent. However, this conflict between compoundhood and stress pattern could be avoided if another analysis of these items is provided – one in which they can be recognized as being idioms, while not assuming that they are compounds. In this way they could be classified along with constructions such as *off the cuff*, *kick the bucket*, *wet behind the ears*, which are neither fully productive nor semantically transparent, and yet which are not classified as compounds. Although they are idioms, in other words, they are not necessarily compounds, and to recognise this would make the link between the syntactic category and the stress pattern more reliable. Bauer (1998) is also sceptical of a straightforward match between syntactic category and stress pattern, but his analysis of compounds is again open to an alternative interpretation. Although the article describes compounds as being indivisible lexical items, in practice it seems that in his analysis the two elements which the compound is composed of are treated as if they were still separate lexical items. For example, considering the case of *blackbird*, an investigation is undertaken to determine which stress pattern *black-* is realized with, and the different contexts which this element appears in, in order to draw conclusions about compounds. This in effect fails to recognize the compound as a compound – *blackbird* is not being treated as an indivisible unit whose components have now been compounded together such that they cannot be analysed outwith the context of the compound as a whole.

Nevertheless, the conclusion which is most usefully drawn for my purposes is to leave these questions as speculative, and simply take the pragmatic line that stress is relevant for my purposes simply because it is the only property which differentiates between these segmentally identical constructions. Since my interest in these pairs is practical rather than theoretical, I am content to exploit those cases where the stress pattern provides the disambiguation, and leave the analysis to one side. As a working guide, however, in the case of the genuinely ambiguous items such as "toy factory" and "steel warehouse", it is possible to treat the first word in the pair as lexically ambiguous between an adjective and a noun, such that when the construction is phrasal it functions as an adjective, and when the construction is a compound it functions as a noun.

One final matter which requires to be discussed in relation to pairs such as 'toy factory' and 'steel warehouse' is more technical, and to some extent terminological. It must be acknowledged that there is a caveat which must be attached to the notion of 'suprasegmental contrasts' in English. As Giegerich (1992) points out, in standard practice, when a minimal pair is found, it is taken as evidence of a phonemic difference, and differences which are phonemic crucially imply unpredictability. If this is applied to the difference between pairs such as ˈ*toy factory* and *toy* ˈ*factory*, however, if the difference is truly a *minimal* difference, we should be able to say that /ˈ./ and /.ˈ/ are 'phonemes' too. The problem with this is that stress is observably not phonemic in English. Rather, the stress patterns are predictable, in the sense that they are reliably associated with particular meanings: the first pattern /ˈ./ is more or less reliably associated with a compound interpretation, while the second pattern /.ˈ/ is more or less reliably associated with a phrasal interpretation. Since it is fundamental to our understanding of phonemes that they are not predictable (the occurrence of /p/ in a word, for example, is not associated with any particular meaning; phonemes have the role of *distinguishing* word meanings, but they do not themselves *have* an associated meaning), the need to recognise that the strong-weak and weak-strong stress patterns correlate with compoundhood and phrasality respectively means that there is some sort of abstract meaning attached to these patterns, which disqualifies it from being 'phonemic'.

In an attempt to avoid the unwelcome conclusion that pairs such as ˈ*toy factory* and *toy* ˈ*factory* indicate that stress in English is phonemic, Giegerich (1992) suggests that the definition of what qualifies as a minimal pair should be revised, so that only mono-morphemic words can be members of a minimal pair (this would clearly rule out compounds and syntactic phrases, both of which are non-mono-morphemic by definition). Yet I would like to suggest that another alternative is also available – not by changing the traditional definition of a minimal pair, but by recognising that the minimal pair test can result in 'false positives'. In other words, although the minimal pair test may well identify *all* the phonemes in a language (if that is the purpose for which it is being used), it does not necessarily identify *only* the phonemes in a language. In case of pairs such as *toy factory*, this would allow us to say that in spite of there being genuine minimal pairs based on stress differences, stress in English is not in fact phonemic when we bring additional (morphological, lexical, and/or syntactic) considerations to bear on the results. This suggestion has the benefit of providing a greater degree of commonality between the approach presented by Giegerich (1992) and that invoked by Ladd (1984) and Vogel and Raimy (2002), as well as making it possible to continue using the familiar term 'minimal pairs' in the present discussion.

Roughly similar phenomena have in fact also been discussed in the literature in the case of Scottish English in particular. Scobbie and Stuart-Smith (2006) provide an extended discussion of the significance of the distinction between pairs such as *side* and *sighed* in Scottish English (the phenomenon known as the Scottish Vowel Length Rule, also exemplified in pairs such as *tide* and *tied*, *brood* and *brewed*, etc). In these pairs, the morphologically simple word has a short vowel, while the morphologically complex word has a long vowel. This means that the length of the vowel could be regarded as a phonemic difference, except that the difference is linked to the word's morphology in a completely predictable way: "while there is a categorical and meaning-bearing difference between the two forms, it is one which is entirely predictable, from morphological structure" (2006: 2). This makes the difference between *side* and *sighed* a very similar phenomenon to the difference between ˈ*toy factory* and *toy* ˈ*factory*: in both cases, the difference is both categorical and meaning-bearing and also entirely predictable (although from syntactic as well as morphological considerations in the 'toy factory' case). Scobbie and Stuart-Smith go on to coin the term 'quasi-phonemic' to cover distinctions such as these – while recognising that the difference is not truly phonemic, they note that the decision to regard it as non-phonemic is based on phonology-external considerations (that is, morphological, lexical, and/or syntactic considerations, exactly as in the 'toy factory' case), and they justify the term *quasi-phonemic* on the grounds that it "gives precedence to the similarity of this pair to other pairs in which a minimal difference in sound makes a difference in lexical meaning" (2006: 2).

In the present discussion, therefore, the term 'suprasegmental contrast' is similarly intended only to refer to the speaker's implicit knowledge that ˈ*toy factory* means something different from *toy* ˈ*factory*, just as the speaker knows that *pat* means something different from *bat* – the minimal difference in sound makes a difference in lexical meaning. Any time that the term 'contrast' is used in this thesis in the context of segmental minimal pairs it is being used in its conventional sense; but on the rare occasion when it may occur in the context of suprasegmental minimal pairs it is never intended to make the claim that the stress patterns themselves are phonemic.

1.4.3 Establishing the existence of the compound/phrasal stress distinction in British English

A pilot study was carried out to establish that this particular suprasegmental difference is indeed a valid contrast in contemporary British English. Sixteen compound/phrasal stress pairs were selected, as listed in the table below. Note that for convenience the constituent elements of the compounds and phrases are labelled 'Word 1' and 'Word 2' (that is, even though in the case of the compounds they are not separate words).

Table 1.1. List of stress-based minimal pairs used in pilot study

Word1+Word2	Compound interpretation	Phrasal interpretation
green+house (practice item)	glass enclosure for growing plants	house which is green in colour
hot+dog (practice item)	sausage snack	dog which is hot
big+top	circus tent	large spinning top
big+wig	important official	large wig
blue+bottle	type of insect	bottle coloured blue
bulls+eye	target of darts board	eye of a bull
head+hunter	employment agent	leader of hunting group
red+neck	someone from the American rural south	neck which is red in colour
tall+boy	chest of drawers	boy who is tall
tight+rope	circus act	rope pulled taut
French+teacher	someone who teaches French	teacher of French nationality
glass+case	place for keeping glass	case made of glass
gold+hammer	tool for working on gold	hammer made of gold
toy+factory	factory producing toys	model factory for children to play with

wood+chopper	tool for chopping wood	axe made of wood
wood+plane	tool for planing wood	aeroplane made of wood

1.4.3.1 Eliciting the stress pattern in production

First it was established that the two syntactic constructions are produced with reliably different stress patterns. One female speaker of Scottish English was asked to read out sentences presented on prompt cards. Each card contained three sentences, the last of which contained either the compound reading or the phrasal reading of a particular pair, while the first two sentences were semantically related. For example, the compound reading *hotdog* was elicited by the sentence triplet, '*I'm going to get a sandwich. I'm going to get a burger. I'm going to get a hotdog*.' The phrasal reading *hot dog* was elicited by the triplet, '*This is a warm cat. This is a cold sheep. This is a hot dog*.' All the sentences eliciting compound readings were presented separately from the sentences eliciting phrasal readings. In this way, the speaker was not made explicitly aware of the contrast of interest.

The sentences were read through three times, and the three tokens of each of the target items were excerpted for examination. When the compound readings were compared with the phrasal readings, two acoustic differences emerged. In the phrasal reading, both Word1 and Word2 were significantly longer in duration than their counterparts in the compound reading (means for Word1: 267 msec in compounds and 335 msec in phrases; $t(17) = 7.272$, two-tailed $p < .001$; means for Word2: 402 msec in compounds and 487 msec for phrases, $t(17) = 8.340$, two-tailed $p < .001$). In addition, in the compound reading, the pitch peak in Word1 was significantly higher than in the peak in Word1 of the phrasal reading (means 247 Hz for compounds and 229 Hz for phrases, $t(17) = 6.809$, two-tailed $p < .001$); pitch was not analysed for Word2 due to difficulties with creaky phonation at the end of the utterances. This female speaker of Scottish English can therefore be seen to produce clearly different stress patterns for the two types of construction.

1.4.3.2 Establishing that the contrast exists for listeners

Secondly it was established that unimpaired speakers of English could act on the difference between compound stress and phrasal stress so as to assign the correct meaning to the different stress patterns. Twelve native speakers of either Southern British English or Scottish English were presented with two pictures, one to represent the compound interpretation and the other to represent the phrasal interpretation, and on hearing either the compound or the phrasal member of each pair they were required to select the picture which matched what they heard. The participants took approximately 2204 msec to respond on average, and the mean score correct was 18.9 out of 28 items, or 67%. A single-sample *t*-test with hypothesised mean 14 showed that this accuracy rate was significantly higher than expected by chance ($t(11) = 5.515$, one-tailed $p < .001$).

1.4.3.3 Comments on the pilot results

The pilot study identified a set of relevant stimuli, established that the distinction between compounds and phrases was reliably produced in Scottish English, and established that the distinction was sufficiently informative for native speakers of British and Scottish English to allow them to select the correct interpretations for the two stress patterns. Some adjustments to the materials was needed (for example, the majority of participants were not familiar with the compound interpretation of *tallboy* (‘chest of drawers’), *big top* (‘circus tent’), or *bigwig* (‘important official’), and the stimulus list required to be expanded, but the results of the pilot were encouraging from the point of view of establishing that the contrast was available both in production and interpretation, and that this task can function as a means of addressing the question of phonological representations which are independent both of orthographic information and of metalinguistic input.

It is also worth noting that these results corroborate the results of a similar study undertaken by Vogel and Raimy (2002). In investigating the acquisition of compound and phrasal stress, Vogel and Raimy (2002) presented similar stimuli to three groups of children (aged approx 5, 7, 9, and 12 years) and a group of adults. Their stimuli consisted of nine pairs with a real compound interpretation (e.g. *hotdog*, *greenhouse*, etc) plus nine items with transparent phrasal interpretations but which do not exist as compounds in English (the so-called novel compounds, e.g., *wet screw*, *split board*, *wood cradle*). One or the other stress pattern was played to participants and they were required to select which of two pictures matched what they had heard.

The stimuli used by Vogel and Raimy (2002) had slightly different acoustic patterns compared to those produced by the Scottish English speaker in my pilot study: in Word1 there was a significantly greater rise in pitch in compounds compared to phrases, and Word2 was significantly longer in phrases than in compounds. There are two reasons why they might have found different acoustic cues – one being that the regional accents are different, and the other being that the patterns were elicited from my speaker without her being explicitly aware of the intended contrast, whereas in Vogel and Raimy (2002), the reader was aiming to produce the two different stress patterns.

The results of Vogel and Raimy (2002) come in two parts. One is their finding that all groups had a preference for assigning compound interpretations rather than phrasal interpretations (i.e. items with compound stress were identified as compounds more often than items with phrasal stress were identified as phrases), and that children showed a much stronger tendency for this preference than adults. This is the same pattern as was shown by the adults in the current pilot study. Vogel and Raimy also found that if the children in their study did not know the meaning of a compound (such as *greenhouse*: a glass house for growing plants), they "overwhelmingly" preferred to assign a phrasal interpretation (i.e., phrasal interpretations were selected regardless of stress pattern). This was the same pattern of behaviour as their participants showed for the novel items (i.e., items which had a "novel", i.e. a nonexistent, compound interpretation). Secondly, and more for developmental interest than direct relevance to my study, their accuracy results for the five groups of participants showed the following pattern. Once unknown and novel compounds were removed from the analysis for each subject, it seems that mean accuracy was around 60% for the 5, 7, and 9 year old groups, around 76% for the 12 year olds, and around 85% for the adults.[10] The main developmental difference thus seems not to be in overall accuracy but in the identification of phrasal stress particularly.

In relation to the question of the phonetics of the difference between compounds and phrases, finally, it should be noted that the production of these syntactic differences can in some circumstances be extremely variable, even to the extent that in some cases, what are structurally compounds may be given 'phrasal' stress (ie end-stress), e.g., *apple 'pie*, *Madison 'Avenue*. This has been noted impressionistically by a number of writers (Fudge 1984, Bauer 1998, Giegerich 2004) and recently also with some quantification (Plag 2006, Kunter & Plag 2007). However, what is important for my purposes is that, what the experiment hangs on is not whether the categories 'compound stress' and 'phrasal stress' are valid in an absolute sense, but that, when stress is required for the purposes of disambiguation, the end-stress

[10] The exact figures for the groups after the unknown and novel items were removed from their scores do not seem to be reported in the article. The estimates which I include here are based on the values shown in Vogel and Raimy's Figure 7.

versus fore-stress distinction gives enough information that the intended meaning can be reliably and dependably indicated.

My pilot study therefore had the function of confirming and supplementing an existing study, as well as providing a foundation for the experiment which will be reported in what follows.

1.5 Aims of the study

The argument which this chapter has been building consists of several related points, which may be recapitulated as follows.

- Spoken language and written language should be regarded as overlapping one another. This overlap is particularly evident in the case of phonemic segments, which can best be understood as the outcome of analyses which model spoken language on written language (§1.3.2).
- Any experimental evidence relating to segmental areas of phonology should therefore be treated with caution in terms of whether it is informative about phonological representations which are specific to spoken language rather than being 'underwritten' or shaped by the speaker's knowledge of written language.
- Metalinguistic skills are qualitatively different from implicit representations. Speakers do not need to engage in metalinguistic analysis for everyday language use: they always know more than they can say, although some of their implicit knowledge can be brought to conscious awareness under the appropriate conditions (§1.3.3).
- Literacy acquisition seems to be one of the conditions under which speakers need to bring their implicit knowledge to conscious awareness. Yet, whatever metalinguistic analysis is required in order for literacy acquisition,

it is a reflection on the form of spoken language in which the learner shapes the sounds of spoken language into categories suggested by conventional orthography – categories which are not inherently present in speech or in the mental representations of speakers as speakers (rather than speakers as readers).

- Tasks such as phoneme deletion and other segmental manipulation tasks draw on these conventional categories and speakers' metalinguistic awareness of them, and they may also draw on short-term or working memory.

In summary, therefore, the first part of the overall argument of this chapter has been that 'phonological representations' refers to representations pertaining specifically to spoken language knowledge rather than knowledge which is conflated with knowledge of written language, and that representations must be clearly distinguished from metalinguistic analyses. The second part of the argument of this chapter is that, whereas in the Phonological Deficit Hypothesis, metalinguistic analysis ability is seen as dependent on the quality of underlying representations, in the viewpoint adopted in this chapter, the two are seen as not at all necessarily related, such that implicit representations of language may well be intact even in the context of a metalinguistic analysis deficit manifested in basic or more challenging tasks. If the metalinguistic skills required for the acquisition of reading are to be regarded as phonology-related, this cannot be understood in the sense of a *representations*-specific skill, but rather a deficit in the application of higher level reflective or meta-phonological cognitive processes. By extension, therefore, if it is correct to identify metalinguistic analysis as the skill which is impaired in dyslexia and causes the reading deficit, this should be seen in all areas of phonology, including those which are not directly related to reading.

The bearing which these issues have on the question of phonological representations in dyslexia was outlined in §1.3.5, where it was pointed out,

(i) that phonological representations need to be considered independently of orthographic input and independently too of metalinguistic analysis,

(ii) that difficulties learning to read and write may not originate with representations of spoken language so much as with the metalinguistic analysis of spoken language which is demanded for reading acquisition, and

(iii) that we need to add to our knowledge about the metalinguistic deficit in segmental phonology in order to ascertain whether the claims of the Phonological Deficit Hypothesis regarding phonology in general should also be taken to include suprasegmental areas of phonology or whether they are restricted to segmental areas (with all the problems which such a restriction would imply in relation to the tautology associated with segmental phonology and orthographic knowledge).

Three research questions are therefore posed, as follows.

Firstly, *are implicit phonological representations impaired in individuals with dyslexia, especially in areas where these representations are not shaped by orthography?*

This question will be addressed in Chapter 2 using the tool of stress-based contrasts which was validated in §1.4. The task piloted in §1.4 firstly allows us to bypass literacy skills by drawing on phonological contrasts which belong strictly to spoken language and have no counterpart in written language. It also allows us to address individuals' representations rather than their metalinguistic analysis skills, by requiring participants to draw on implicit phonological knowledge but only so as to assign an interpretation to a piece of phonological information – i.e. without being required to introspect or consider any of the properties of the form of the phonological material.

The predictions which are made by the Phonological Deficit Hypothesis vary depending on what claims it is understood to be making when it invokes 'phonological representations' without specifying whether these representations are only segmental or both segmental and suprasegmental. Two alternatives are therefore possible. In the broader sense, where 'phonological representations' refers to both segmental and suprasegmental areas of phonology, the prediction is that individuals with dyslexia should show a deficit relative to non-dyslexic individuals in the interpretation of stress-based contrasts as this was tested in the pilot task in §1.4. Alternatively, in the narrower sense, where 'phonological representations' refers only to segmental areas of phonology, the prediction is that individuals with dyslexia should not be impaired in the interpretation of stress-based contrasts.

On the other hand, the prediction which arises from the argument which has been advanced in this chapter is that, since only implicit knowledge is required, and particularly since it is implicit knowledge of phonological patterns which are not represented orthographically, individuals with dyslexia will not show any impairment in the interpretation of stress-based contrasts. In the following chapters I will refer to the argument which has been put forward in this chapter as the 'metalinguistic hypothesis'.[11]

Secondly, *do individuals with dyslexia have an impairment in the ability to focus on the form of spoken language*, whether or not they have a deficit in the representation of it?

This question will be addressed in Chapter 3, using a task in which participants are required to identify or recognise phonologically relevant contrasts within spoken words. This represents one way of testing basic metalinguistic analysis skills, that is, the ability to focus on the form of a word rather than access its meaning. It does not test representations as such, but rather the ability to reflect on the form of spoken language, treating it as something which can be 'looked at with the mind's eye' as an object of investigation in its own right. It is widely accepted that such a skill is necessary for successful reading acquisition, but it is not clear whether the deficit in

[11] I am grateful to my examiners, Prof B Wells and Dr L Kelly, for suggesting this label.

this skill which has been observed in individuals with dyslexia when the phonological units are segmental will also extend to tasks where the phonological units are suprasegmental. By including a stress-based metalinguistic task alongside a segmental metalinguistic task, therefore, Chapter 3 will begin to address the issue of whether the 'phonological deficit' in dyslexia extends to the metalinguistic analysis of suprasegmental units, as well as segmental units.

The broader reading of the Phonological Deficit Hypothesis, in which both segmental and suprasegmental areas of phonology are assumed to be impaired in dyslexia, predicts that a deficit will be shown by individuals with dyslexia in the metalinguistic identification or recognition of both segmental and suprasegmental units. The narrower reading of the hypothesis, in which only segmental areas are said to be impaired, predicts that a deficit will be seen only in the metalinguistic recognition of segmental units.

Meanwhile, the prediction which follows from the argument presented in this chapter is that individuals with dyslexia will show deficits in the metalinguistic analysis of both segmental and suprasegmental aspects of spoken words, simply on the basis of the metalinguistic nature of the demands made in this task and regardless of phonological domain.

Thirdly, does dyslexia involve *an impairment in the ability to extract and manipulate arbitrarily specified phonological units from within words*?

This question is broken down into two sub-questions and addressed in Chapters 4 and 5. These chapters make use of two conventional segmental manipulation tasks – a pig Latin task in Chapter 4 and a spoonerism task in Chapter 5 – along with novel versions of these tasks in which suprasegmental units rather than segmental units are required to be manipulated in an analogous way. These two tasks differ in their complexity, in that the pig Latin task requires only one phonological unit to be manipulated, whereas two units are involved in the spoonerism manipulation.

The ‘broad’ reading of the Phonological Deficit Hypothesis predicts that deficits will be shown by dyslexic participants in both segmental and suprasegmental versions of these two manipulation tasks. The ‘narrow’ reading of the hypothesis predicts that deficits will be seen only in the segmental versions.

On the other hand, on the basis that these tasks involve metalinguistic analysis and metalinguistic manipulation, the argument presented in the current chapter predicts that deficits will be seen in both versions of the two tasks, irrespective of phonological domain.

In the chapters which follow, Chapters 2 to 5 report the tasks which were used to address the three research questions posed above, and the results of comparing the performance of dyslexic and non-dyslexic participants in these tasks. Finally, Chapter 6 will present a discussion of the results of these experiments as a whole, highlighting and discussing the implications which follow from the findings.

Chapter 2

The Interpretation task

2.1 Introduction

The purpose of the experiment reported in this chapter is to make use of the phonological concept of contrast to explore the extent to which participants with dyslexia might differ from controls in their representation of phonologically contrastive units, that is, when no metalinguistic demands are imposed and when (in the case of the suprasegmental version) no orthographic information is available. The task is called the Interpretation task, as it aims to test the participants' ability to assign the correct meaning to one or the other member of a minimal pair. There are two versions of this task – a segmental and a suprasegmental version using, respectively, segmental and suprasegmental minimal pairs.

In the segmental version of this task, the predictions of the Phonological Deficit Hypothesis are clear: on the basis of the claims that segmental representations in dyslexia are fuzzy or degraded, it should be expected that individuals with dyslexia will perform less successfully than non-dyslexic individuals in this version of this task. However, when performance is tested in the suprasegmental version (that is, using stimuli which consist of stress-based minimal pairs), the predictions of the Phonological Deficit Hypothesis are less clear. Taking the claim of impaired representations in its broad sense, both segmental and suprasegmental representations are assumed to be impaired, and so it would be predicted that the individuals with dyslexia would perform the suprasegmental version of this task less successfully than non-dyslexic participants. On the other hand, if the claim of impaired representations is intended to be restricted to segmental phonology, then the Phonological Deficit Hypothesis taken in this narrower sense does not predict that there will be a deficit in the suprasegmental version of this task. This second outcome is also what is expected from the perspective of the arguments I have been advancing in Chapter 1 (summarised in §1.5). That is, if it is the case that the phonological representations deficit is tautologically related to the known difficulties of individuals with dyslexia in mastering orthographic literacy, then it is predicted not only that performance will be weaker in the segmental version of this task but also that no deficit in performance will be seen in the suprasegmental version. The predictions arising from my argument in Chapter 1 in this way coincide with the predictions made by the Phonological Deficit Hypothesis taken in the narrower sense, although they arise from different assumptions and considerations.

This chapter begins by presenting the materials which were used in this task, first in the segmental and then in the suprasegmental version (§2.2.1 and §2.2.2 respectively). Details are presented in §2.3 for the two groups of participants (the group of individuals with dyslexia, and the group of individuals with no history of dyslexia), including their performance on measures of reading and spelling ability. The experimental procedure is then outlined in §2.4.

In the results section (§2.5), the overall results of the relevant task are presented first (that is, the outcome of comparing the segmental and suprasegmental versions of the task in question). Then the segmental and the suprasegmental versions of the two tasks are examined separately in more detail, with a view to examining what further light can be shed on their performance depending on the types of materials used. The results are then discussed in §2.6 in terms of their bearing on the Phonological Deficit Hypothesis.

In §2.7, a further set of results is presented: the results of investigating what if any relationship holds between the performance of the two groups on the Interpretation task, and their literacy abilities. As will be detailed in §2.3, the literacy skills of the participants in both groups were measured by two subtasks of the Wide Range Achievement Test (WRAT), namely the Reading and Spelling subtasks. According to the claims of the Phonological Deficit Hypothesis, literacy difficulties in the dyslexic population can be traced back to underlying phonological representations, with grapheme-to-phoneme correspondences playing a large part in successful literacy acquisition. On the other hand, although it has frequently been shown in the literature that various measures of phonological awareness skills correlate significantly with measures of literacy ability, reading development is also related to some degree by other linguistic measures such as early syntactic skills, and prosody-related skills which are not directly relevant to facility in an alphabetic script. Furthermore, because the step from phonological awareness back to underlying phonological representations is often made on conceptual grounds, it remains important not only to measure phonological representations independently of metalinguistic input but also to establish whether performance on a test of phonological representations has any relation to literacy skills. As was shown in some of the studies reviewed in Chapter 1, for example, it is possible that suprasegmental skills similar to those tested by the Interpretation task may also show a relationship with reading ability. If there is no relationship between the performance of the group of dyslexic participants on the Interpretation task and their literacy abilities, this would potentially call into question what skills lie behind the phonological awareness tasks which are generally found to be related to literacy ability – in other words, the skills which are indexed by performance on existing phonological awareness tasks, while they are correlated with reading and spelling abilities, may not be as informative about individuals' phonological representations as they have often been taken to be. It is also conceivable that literacy ability could be linked to the segmental tasks but not the suprasegmental tasks, a finding which would be potentially problematic for the Phonological Deficit Hypothesis, as it would not allow us to escape from the tautology where segmental skills (but not suprasegmental skills) are reflected in and supported by literacy experience. Because it is possible that correlations may be found between literacy and the Interpretation task even though phonological representations such as are tested by the Interpretation task may not be critical for literacy acquisition, if correlations are found between performance in the Interpretation task and the literacy measures this will not necessarily help to distinguish between competing theories of the relation between phonological representations and literacy ability or acquisition. However, since the Phonological Deficit Hypothesis makes it very clear that representations are believed to be the source of the metalinguistic deficits which lead to literacy difficulties, if the Phonological Deficit Hypothesis is to be supported by the data collected in this study, correlations should be found between the literacy measures and performance on the Interpretation task.

The final section of the chapter, §2.8, will then draw together the main issues arising from the discussion of the results of this chapter in relation to the implications primarily for the Phonological Deficit Hypothesis.

2.2 Interpretation task materials

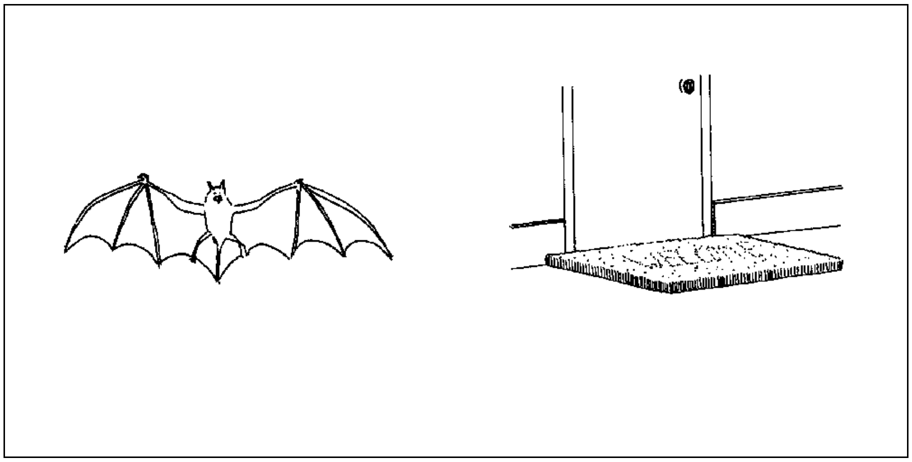
2.2.1 Materials for the segmental Interpretation task

The segmental version of this task consisted of the 38 monosyllabic words with a CVC structure which are used in the 'Minimal pair discrimination with pictures' subtask of the *Psycholinguistic Assessments of Language Processing in Aphasia* (PALPA) (Kay, Lesser, and Coltheart 1992). Two of the words were used as practice items and were not included in scoring. Each word belonged to a minimal pair which contrasted either word-initially (e.g. *bat*, *mat*) or word-finally (e.g. *back*, *bag*). The complete stimulus list is provided in Appendix B.

Auditory stimuli were read out from lists by a number of different speakers, all of whom were native speakers of Scottish Standard English. The lists produced by each speaker were examined in terms of how clearly the items were pronounced and how consistent the intonation pattern was for each item (i.e. whether a neutral citation form was produced for each word, rather than indicating that the items were read in a list), and the speaker whose productions were judged to be most clear and consistent was chosen for each task. Speakers read out both members of each minimal pair in isolation from a randomised list, but only one member of a pair was used in the experiment. The selected speaker for this task was a female native speaker of Scottish English who was phonetically trained as a qualified speech and language therapist.

Each word was matched with two pictures, corresponding to the two members of that minimal pair (e.g. the soundfile 'bat' was matched with pictures of a bat and a mat). The visual materials were also taken from the 'Minimal pair discrimination with pictures' subtask of the PALPA with permission from one of its authors. The image for each possible interpretation measured approximately 300x300 pixels and the images for each minimal pair were placed side by side on the computer screen, as shown in Figure 2.1.

Figure 2.1. Sample screenshot for segmental Interpretation task



Note that this task is a modification of the PALPA subtask in several ways. In terms of the auditory materials, for this task the items were pre-recorded and presented to participants in a randomised order, rather than being read aloud by the experimenter for each individual participant. In terms of the visual materials, participants are presented with two pictures to choose from, namely, only the target item and its minimally different counterpart, rather than three pictures (the members of the minimal pair and another distractor item, such as *cat* along with *bat* and *mat*). The pictures are also presented side by side horizontally, rather than one above the other vertically, as in the PALPA. Finally, two of the PALPA items were reserved and used as practice items, resulting in 36 of the original 38 items being used as experimental items. These were the only modifications which were required to make the format of this task equivalent to the format of the suprasegmental version of this task.

2.2.2 Materials for suprasegmental Interpretation task

The suprasegmental version of this task consisted of 42 items, half of which were stress-based minimal pairs and half were fillers. As in the pilot study reported in §1.5, the minimal pairs were of two types, the 'genuinely ambiguous' type and the 'idiomatic' type. There were equal numbers of ambiguous and idiomatic items.

The genuinely ambiguous type included items such as *toy factory* and *German teacher*, i.e. sequences of nouns preceded either by another noun (in which case they are N+N compounds, and realised with compound stress) or by an adjective (in which case they are Adj+N phrases, and realised with phrasal stress). These sequences rely wholly on their stress pattern in order to be correctly interpreted.

The idiomatic items included *hot+dog* and *wet+suit*. It should be noted again that as compounds (i.e. when the string is produced with compound stress) these items are by definition lexical items, with an idiomatic or nontransparent meaning (*hotdog* 'frankfurter'; *wetsuit* 'protective clothing used by surfers'), yet when these items are produced with a phrasal stress pattern, they can straightforwardly take on a plausible phrasal interpretation (*hot dog* 'canine which has the property of being hot'; *wet suit* 'type of clothing which has the property of being wet'). Note again that these phrasal counterparts are not somehow derived from the compounds themselves – they are constructed by normal syntactic processes which are entirely productive and fully semantically transparent. Because of the fact that the idiomatic items therefore consist of two different grammatical constructions, and because the compound-stressed idiomatic items may be distinguished from their phrasal counterparts orthographically as well as by their stress pattern, this set of items is less ideal than the 'genuinely ambiguous' items in terms of suitability for addressing the research question.

Filler items consisted either of compound nouns (*orange juice* vs *apple juice*; *bookshelf* vs *bookstall*) or Adj+N phrases (*red boat* vs *blue boat*; *pink handbag* vs *pink flower*).

Each item from all three categories (genuinely ambiguous, idiomatic, and filler) was located in the carrier frame, "This is what a ______ looks like." This ensured that the item of interest was located sentence-medially, avoiding possible interference with prosodic phenomena such as phrase-final lengthening which could obscure the differences between compound and phrasal stress. The carrier frame was also neutral in terms of providing any syntactic context which could help to disambiguate the minimal pairs on any basis other than the stress pattern itself. The complete stimulus list is provided in Appendix B.

The pilot testing in §1.5 had confirmed that the compound/phrasal contrast did exist in Scottish English: statistically significant acoustic differences were found in both duration and pitch when speakers read the members of each pair separately without being made aware of the contrast being elicited. However, piloting had also showed that the contrast was made most clearly when the both members of a pair were read side by side by a speaker who was aware of the contrast. This was therefore how the items were presented for the speaker to read.

The speaker who made the contrast most clearly (and whose productions were therefore selected to constitute the auditory stimuli for this task) was a female native speaker of Scottish English, phonetically trained as a student of linguistics. Pitch and duration measurements for this speaker are provided in Table 2.1 below.

Table 2.1. Pitch (Hz) and duration (msec) in the suprasegmental Interpretation materials

	Word1 (e.g. *toy*)		**Word2 (e.g. *factory*)**	
	Pitch: mean (sd)	**Duration: mean (sd)**	**Pitch: mean (sd)**	**Duration: mean (sd)**
Compound	267.9 (33.3)	305.9 (87.7)	210.3 (14.0)	317.5 (102.0)
Phrasal	201.3 (11.6)	280.4 (67.8)	237.7 (21.3)	369.2 (87.5)

Pitch of Word1 was higher in compounds than in phrases ($t(20) = 9.748$, two-tailed $p < .001$), while pitch of Word2 was higher in phrases than in compounds ($t(20) = 5.347$, two-tailed $p < .001$). The duration of Word1 was longer in compounds than in phrases ($t(20) = 2.890$, two-tailed $p = .009$), and the duration of Word2 was longer in phrases than in compounds ($t(20) = 8.563$, two-tailed $p < .001$). In sum, compounds had higher pitch and longer duration in Word1 compared to phrases, while phrases had higher pitch and longer duration in Word2 compared to compounds.

From this list of pairs, one member from each pair was randomly selected to be presented to participants. Pitch and duration measurements for these individual items are presented in Table 2.2, with compound and phrasal realisations of ambiguous items shown separately from realisations of idiomatic items. Note that the duration measurements in Table 2.2 refer to the duration of the lexically stressed syllable in the relevant word (not the duration of the whole word, as was the case in Table 2.1). Lexically stressed syllables are measured in this case rather than the whole word due to the fact that the items differ in the number of syllables they contain. The range of values is reported rather than the standard deviations since the number of items in each category is relatively small (there were 6 ambiguous items with compound stress and 5 with phrasal stress, 4 idiomatic items with compound stress and 6 with phrasal stress).

Table 2.2. Pitch (Hz) and duration (msec) of suprasegmental Interpretation materials, showing ambiguous and idiomatic items separately

	Word1 (e.g. *toy* or *hot*)		Word2 (e.g. *factory* or *dog*)	
	Pitch: mean (range)	Duration: mean (range)	Pitch: mean (range)	Duration: mean (range)
Ambiguous Compound	290.5 (245.0-384.0)	213 (140.2-313.0)	209.0 (182.8-224.2)	262.4 (172.3-347.0)
Idiomatic Compound	256.9 (239.4-273.4)	297.8 (240.0-359.0)	213.1 (210.7-214.9)	229.4 (193.0-259.0)
Ambiguous Phrase	207.4 (195.7-239.5)	214.4 (147.0-336.0)	266.3 (249.5-287.6)	229.4 (162.1-348.0)
Idiomatic Phrase	199.7 (188.5-214.5)	263.2 (191.9-325.0)	222.2 (207.5-245.6)	303.7 (145.9-361.0)

Each of the selected items was matched with two pictures, corresponding to the two members of that minimal pair (e.g. the soundfile 'hotdog' was matched with the pictures of a dog panting in the heat and the sausage-filled roll). The pictures were drawn specifically for the task by volunteers. Pictures were presented side by side on the computer screen. Sample images are shown below for *toy+factory* (Figure 2.2) and *hot+dog* (Figure 2.3), and also for the filler item *apple/orange+juice* (Figure 2.4). Note that these samples are not identical to the visual display which was viewed by participants; in the experimental presentation, each of the two options measured approx 300 x 300 pixels and they were located equidistant from the centre point of the screen.

Figure 2.2. Sample pictures for suprasegmental Interpretation task (*toy factory*, a genuinely ambiguous item)

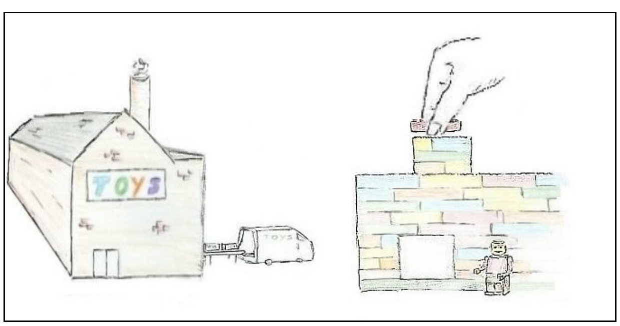


Figure 2.3. Sample pictures for suprasegmental Interpretation task (*hot dog*, an idiomatic item)

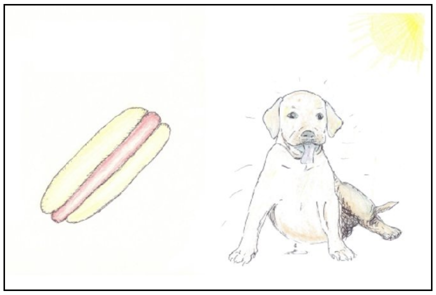
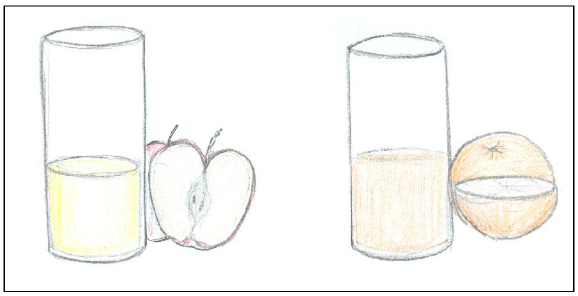


Figure 2.4. Sample pictures for suprasegmental Interpretation task (*apple juice/orange juice*, a filler item)



2.3 Participant details

Participants were all university students, recruited from universities in Edinburgh. They all spoke English as their native language, and they were all required to be studying a subject other than linguistics, in order to ensure that they had not had any special training in metalinguistic analysis or practice with phonological manipulation. The rationale for testing students came partly from the expectation that the tasks were likely to be too difficult for children (see Vogel & Raimy's (2002) results, and the results of the pilot study (§1.5) that unimpaired adults do not perform at ceiling on what might be called the easiest of the tasks in the battery). It was also in part motivated by the argument put forward by, for instance, Pennington et al (1990), that in addition to being shared by all the individuals with a particular disorder, and ideally specific to the disorder itself, “deficits that last into adulthood and that are found in individuals who have compensated for other symptoms of the disorder are good candidates for underlying deficits” (Pennington et al 1990: 1754).

The dyslexic group consisted of twenty-one students who had been given a formal diagnosis of dyslexia at any age (7 males and 14 females). The mean age was 24;2 years (range 17;5-41;4). Their regional accents were self-reported as English (n = 12), Scottish (n = 6), and one each of American, Northern Irish, and Irish. Fifteen of these participants stated or estimated the age at which they were given the diagnosis of dyslexia; a third of them were diagnosed as dyslexic before leaving primary school, and the rest were diagnosed either during high school or at university. The majority were studying a subject in the Arts, Humanities, and Social Sciences (n = 12), and the rest were studying Medicine and Health Sciences (n = 5) or Science and Engineering (n = 3). The characteristics of the group as a whole are presented in Appendix A. Potential participants were excluded if they reported hearing loss or additional diagnoses such as dyspraxia.

The control group consisted of twenty-one students who had no history of speech/language difficulties and had never been diagnosed as dyslexic (7 males and 14 females). The mean age was 24;1 (range 17;6-42;5). Their regional accents were self-reported as English (n = 14), Scottish (n = 3), American/Canadian (n = 3), and Northern Irish (n = 1). The majority were studying a subject in the Arts, Humanities, and Social Sciences (n = 15) and the remainder were studying Science and Engineering (n = 5). One potential control was excluded when she reported that she was the only member of her family, including siblings, parents, and grandparents, who had not been formally diagnosed with dyslexia. Potential participants were also excluded if they were studying languages or linguistics. The details for each participant are shown in Appendix A.

Three background tasks were administered to all participants to confirm the self-reports of dyslexia for the participants in the dyslexic group. These were both the Reading and the Spelling subtests of the Wide Range Achievement Test (WRAT-3) (Wilkinson 1993), and the British Dyslexia Association (BDA) Checklist. Note that the key inclusion criterion for the study was a formal diagnosis of dyslexia; these tasks were not administered with the purpose of ruling individuals in or out of the study, but only to confirm that the groups differed (in the expected direction) on their reading and spelling skills.

The WRAT is widely used in the research literature, where it is commended by McLoughlin (1997) on methodological grounds (it was standardised on "a stratified, representative sample of 5000 individuals from forty-nine American states," and has good reliability and validity figures), although he does include the caveat that it may be "too specific to American curricula" for unquestioning use in all situations. In the WRAT Reading test, 42 single words are presented as a printed list, ranging from easy (e.g. *book, tree*) to more difficult (e.g. *egregious*, *assuage*). Participants' responses to the reading task were recorded and subsequently phonetically transcribed and scored offline. In the WRAT Spelling test, participants are required to spell a single word which is read aloud by the experimenter first in isolation then in a sentence (e.g., "Decision. Her decision was accepted by all;" "Enthusiasm. People showed enthusiasm for the hero"). Again the task proceeds from easy items (*enter*, *light*) to harder items (*cacophony*, *camouflage*). For the present study, the words and sentences were not read aloud by the experimenter but were pre-recorded as read by the same Scottish female speaker who was selected for the segmental Interpretation materials as reported above. This ensured that all the participants heard the same productions of the items.

The third background task was the British Dyslexia Association Checklist. This is a more informal test, consisting of a questionnaire with twenty items which require either a 'yes' or 'no' response (e.g. 'Is your writing difficult to read?' 'Do you find difficulty telling left from right?'). These questions can be answered subjectively, and the expectation is that an individual who is likely to have dyslexia will answer the majority of the questions with a 'yes' response (McLoughlin, Fitzgibbon, & Young 1994). However, because it addresses skills such as memory, time management, and skills other than those directly related to literacy, it can give an impressionistic indication of the broader context of an individual's strengths and weaknesses, in much the same way as is done more formally in clinical diagnosis.

Note that since all the participants were studying at university, it was reasonable to assume that their non-verbal IQ was at least in the normal range, and no formal measure of IQ was taken. It may be noted that although the equivalence of the groups in general cognitive terms was not specifically tested as a prerequisite for participating in the study, post hoc inspection of the overall results shows that the two groups did not differ on indicators such as their comprehension of the task instructions, and none of the participants in the dyslexia group reported other cognitive or learning disabilities.

On all three of the background measures, the dyslexics had scores in the expected direction. For the Reading task, the dyslexics' mean standard score of 98 (range 77-116, sd 9.9) was significantly lower than the controls' mean standard score of 108 (range 92-118, sd 7.1), $t = 3.544$, $df = 18$, two-tailed $p = .002$. For the Spelling task, the dyslexics' mean standard score of 101 (range 73-114, sd 9.6) on the spelling task was significantly lower than the controls' mean standard score of 110 (range 103-119, sd 5.3), $t = 3.921$, $df = 18$, two-tailed $p = .001$. The distribution of the reading and spelling standard scores for both groups can be seen in Figure 2.5 and Figure 2.6 below. These scores for the two groups are comparable to those which have been reported in other studies of students with dyslexia at university or about to enter university (e.g. Gallagher et al 1996, Hatcher et al 2002, Ramus et al 2003). Note that following the practice of Ramus et al (2003), whose dyslexic participants were students at University College London, it was confirmed that none of the participants with dyslexia had a combined mean reading and spelling standard score which was greater than 110. As can be seen from the figure below, all but two of the students in the dyslexic group had standard scores of less than 110 on both the reading and spelling task; one had a reading standard score of 116 combined with a spelling standard score of 103, which averages to less than 110; the other had a spelling score of 114 but her reading data was not collected due to technical problems with the recording equipment.

Figure 2.5. Distribution of participants' WRAT Reading scores

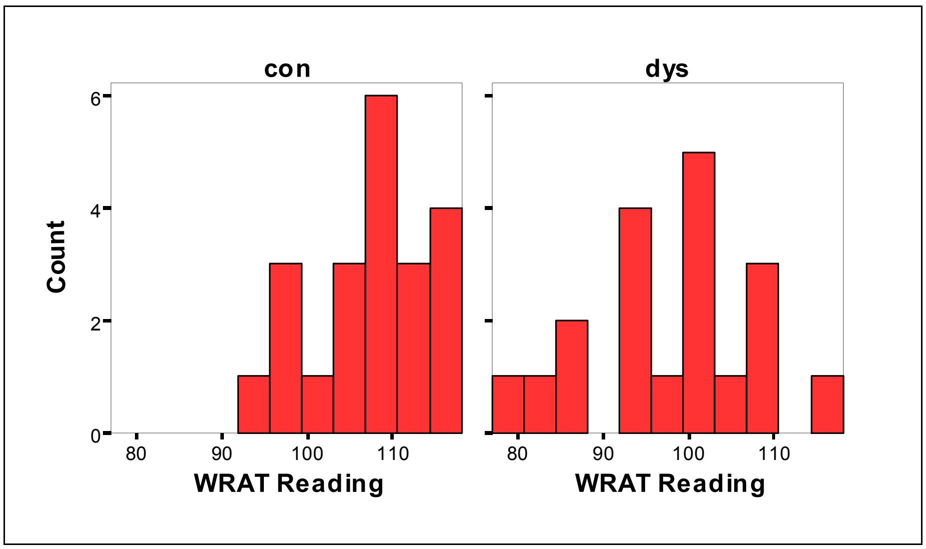
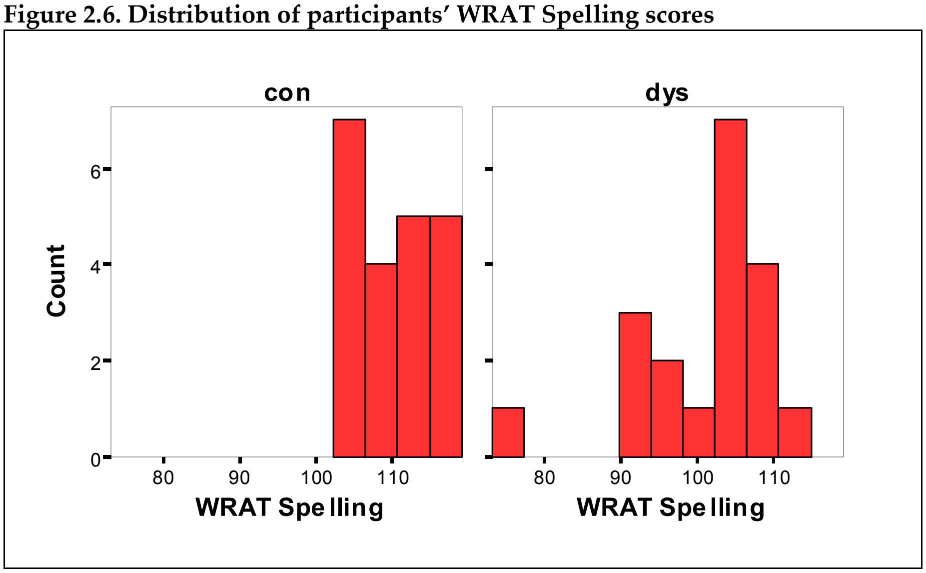


Figure 2.6. Distribution of participants' WRAT Spelling scores



The responses to the British Dyslexia Association checklist further confirmed the self-reported diagnosis of dyslexia: the dyslexic group made significantly more 'yes' responses than the control group (dyslexic mean 11.9, range 7-19, sd 3.7; control mean 4.7, range 2-10, sd 2.1; $t = 8.842$, $df = 20$, two-tailed $p < .001$).

Participants were matched for gender and age (mostly within 2 years), and also for regional accent as far as possible. In virtue of being recruited from university, they also shared the same level of education. They were each paid the hourly national minimum wage for taking part (either £5.05 or £5.35 depending on when they were tested).

2.4 Procedure for Interpretation task

Participants were tested individually. The order in which the participants were administered the two versions of the Interpretation task was varied systematically along with the order of presentation for the two versions of the Recognition task (to be reported in Chapter 3). Participants were presented either with both the segmental versions of these two tasks prior to both the suprasegmental tasks, or else with both the Interpretation tasks prior to both the Recognition tasks. The rationale for varying the order of tasks in this way was partly based on the expectation that the suprasegmental tasks would be more difficult, and more difficult to understand, and that by taking part in the segmental version of each task the participants would find it more straightforward to grasp the task demands for the suprasegmental versions. It was also intended that by staging the tasks in order of increasing metalinguistic demands, the amount of metalinguistic analysis which a participant might undertake in the Interpretation task would be kept to a minimum, or in other words, this order of tasks was intended to avoid a situation where participants would be taking part in tasks supposedly testing implicit categorisation after having been effectively trained in listening for the same kinds of categories in an earlier task. It took approximately 20 minutes for the participants to complete both versions of the Interpretation and Recognition tasks.

For all the tasks (including those reported in the following chapters), participants were seated in a sound-deadened booth facing a computer monitor with a keyboard. The auditory stimuli were presented through headphones and participants made their response using specified keys on the keyboard. Since all the tasks demanded a response to two options presented on the screen, the same keys were used throughout the experiments; the keys chosen were "Z" and "M" (the keys at opposite sides of the keyboard) to choose the option presented on the left hand side of the screen and the right hand side, respectively. Participants were encouraged to use the forefinger of each hand in order to make their response as rapidly as possible, but in all cases, participants were given as much time as they needed to make their response; subsequent trials did not begin until after the previous response was made. There was always a pause of one second after the participant's response before the start of the next trial.

In both versions of the Interpretation task, participants were instructed to select the picture which matched the word or sentence which they heard. Pictures and sounds were presented simultaneously. Participants made their choice of picture based on the two pictures presented side by side on the screen (i.e. either the one on the left or the one on the right hand side). The position of the pictures was counterbalanced so that the correct picture was located on the left hand side of the screen as often as on the right hand side, and in the suprasegmental version, the picture locations were also counterbalanced to ensure that pictures corresponding to the compound interpretation were presented on the left hand side of the screen as often as on the right hand side. There was one second's pause after the participant made his/her response before the next sound was played.

Verbal instructions were provided by the experimenter to each individual participant, and the same instructions were also provided on-screen before the task began, with the only difference that the verbal instructions included example words, and the on-screen instructions did not. Examples were avoided in the on-screen instructions as they would necessarily have been written, and it was important to encourage participants to deal in terms of the auditory material they were hearing, rather than the orthographic form of written words. (The instructions are provided in Appendix B.)

Each task was presented using E-Prime (Psychology Software Tools, Pittsburgh, PA).

2.5 Results of the Interpretation task

Both accuracy and response time data were collected for each task. The following points should be noted in relation to the measurement of accuracy in this task (and in the tasks reported in the following chapters). Because the experimental paradigm in use for this task was the two-alternative forced choice task, it was preferable to use signal detection theory to measure the accuracy of participants' responses, rather than, for example, percentages of correct items. Accuracy was therefore measured using *d*′, a test of discrimination sensitivity which relies on the difference between *z*-transformed rates of the participant's 'hits' (choosing the correct option) and 'false alarms' (choosing the wrong option) (Macmillan & Creelman 2005). In the present context, using the suprasegmental Interpretation task as an example, a participant's hit rate is calculated as the proportion of responses which (correctly) identified items with compound stress as being compounds; the false alarm rate is the proportion of responses which (incorrectly) identified items with phrasal stress as being compounds. This can be illustrated in the following chart, bearing in mind that, as Macmillan and Creelman (2005: 167) point out, the terminology (in terms of hits and false alarms) is arbitrary in the particular case of two-alternative forced choice tasks.

Table 2.3: Illustration of possible responses in the suprasegmental Interpretation task as required for *d′* analysis.

		Participant's response		Number of trials	Calculation
		"compound"	"phrase"		
Stimulus type	**compound stress**	15	3	18	Hit rate = 15/18 = 0.83
	phrasal stress	4	14	18	False alarm rate = 4/18 = 0.22

The basic means of calculating *d′* is by finding the difference between the *z*-transformed hit rate and the *z*-transformed false alarm rate. In the particular case of two-alternative forced choice tasks, however, this value is then adjusted downwards by a factor of √2, as shown in the following formula:[1]

$$d' = [1/\sqrt{2}] \times [\ z(H) - z(F)\ ]$$

where *H* is the proportion of 'hits' and *F* is the proportion of 'false alarms'. It should further be noted that when proportions of 'hits' and 'false alarms' are equal to 0 or 1, this gives rise to infinite values for *z*, which means that *d′* is undefined. In these instances, Macmillan and Creelman's conversion procedure was followed: specifically, proportions of 0 are converted to $1/(2N)$ and proportions of 1 are converted to $1–1/(2N)$, where *N* is the number of trials on which the proportion is based. For a full discussion of how *d′* values relate to percentage accuracy scores, the

[1] The adjustment by a factor of √2 is required only for two-alternative forced choice tasks (such as this task and the task reported in §3); the adjustment compensates for the fact that these are easier than other kinds of task, such as 'Yes-No' tasks. 'Yes-No' tasks are in fact used in the experiments reported in Chapters 4 and 5. In these experiments accuracy is also measured using *d′* but this correction is not required. This will be noted again in the relevant sections (§4.5 and §5.5).

reader is referred to Macmillan and Creelman (2005). As a rule of thumb, however, it may be noted that *d′* scores close to 0 reflect performance around chance levels (perfect discrimination in a two-alternative forced choice task gives an infinite value for *d′*).

Response time was measured in milliseconds, for correct responses only. For each individual participant, response times which were longer or shorter than 2 standard deviations from their mean response time were discarded, as were the corresponding choices.

2.5.1 Overall results for the Interpretation task

The Interpretation task aimed to test how well the participants would be able to use the meaningful difference between minimal pairs in order to make the correct interpretation of the word or phrase they listened to (e.g., so as to interpret the sound /kot/ as referring to a coat /kot/ rather than a goat /got/, or, analogously, so as to interpret the sound /ˈhɔt.dɔg/ as referring to a frankfurter /ˈhɔt.dɔg/ rather than an animal /hɔt.ˈdɔg/). The minimal pairs were either segmental (*coat*/*goat*) or else stress-based (*hotdog*/*hot_dog*). In line with the view that individuals with dyslexia have impaired or fuzzy phonological representations, it was expected that the dyslexic group would perform worse than the control group on the segmental task. For the suprasegmental task, if the phonological representations deficit extended to the representation of suprasegmental contrasts, as implicitly predicted, or at least not ruled out, by the Phonological Representations Hypothesis, the dyslexic group would be expected to find this task more difficult than the control group too.

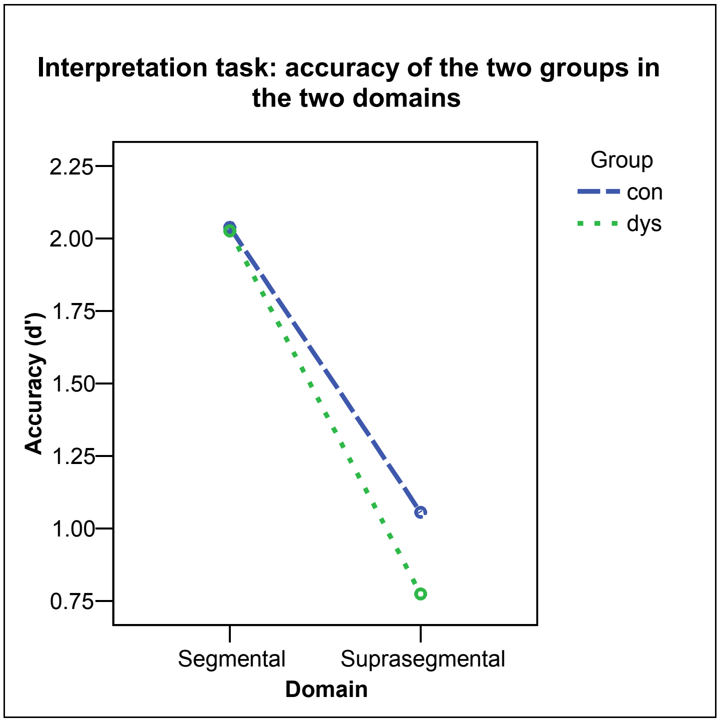
As mentioned above, accuracy was measured using *d′* and this measurement rather than percentage correct is used for analysing the performance of the groups. The group means and standard deviations are reported in Table 2.4. For information, accuracy rates expressed as percentages of correct responses were 92.6% and 92.5% in the segmental version of this task for the control group and the dyslexic group respectively, and 71.7% and 64.8% respectively in the suprasegmental version.

Table 2.4: Accuracy (*d'*) for segmental and suprasegmental versions of the Interpretation task

	Segmental version: mean (sd)	**Suprasegmental version: mean (sd)**
Control	2.04 (0.22)	1.06 (0.63)
Dyslexic	2.03 (0.27)	0.77 (0.62)

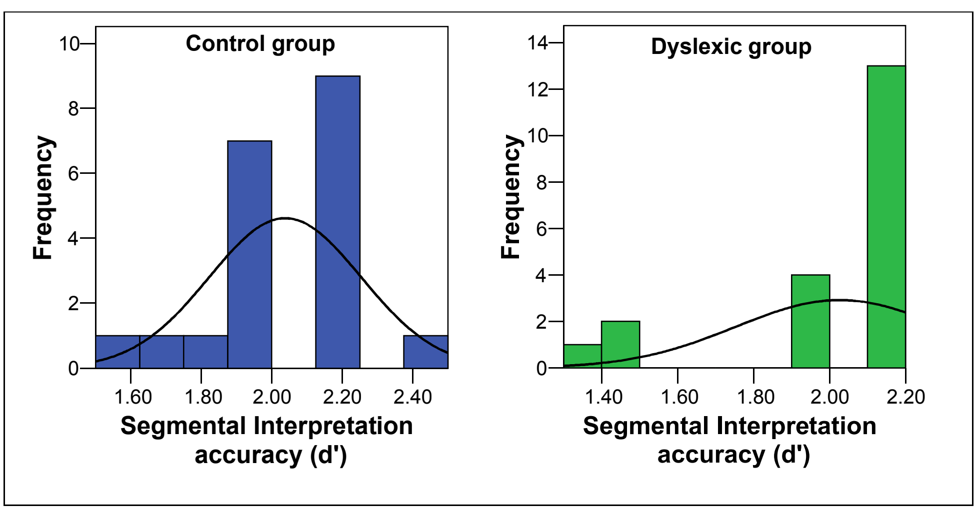
A 2x2 mixed ANOVA was carried out with accuracy as the dependent variable, phonological Domain as a within-subjects independent variable, and Group as a between-subjects independent variable. There was no effect for Group ($F(1, 38) = 1.491$, $p = .230$). There was a significant main effect for Domain, with lower accuracy in the stress version than the phoneme version ($F(1, 38) = 150.490$, $p < .001$). There was no interaction ($F(1, 38) = 2.194$, $p = .147$). This is shown in Figure 2.7.

Figure 2.7. Accuracy in the segmental and suprasegmental versions of the Interpretation task



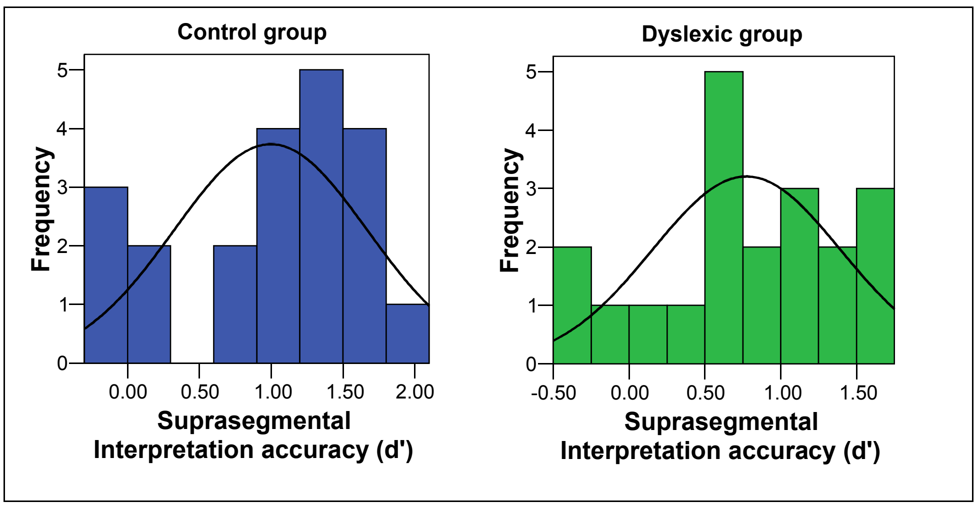
Further details can be provided in connection with the high accuracy scores of the two groups in the segmental version of the Interpretation task. Figure 2.8 shows the distribution of both groups' scores.

Figure 2.8. Distribution of accuracy scores in segmental Interpretation task



Inspection of these distributions suggests that although the scores of the control participants are approximately normally distributed, the negative skew seen in the dyslexic group is indicative of a ceiling effect in the segmental Interpretation scores. This is confirmed by a Kolmogorov-Smirnov test for normality (for the control group, Z = .956, p = .321; for the dyslexic group, Z = 1.550, p = .016), indicating that these results will need to be interpreted with caution (§2.6). No such skew is observed in the results for the suprasegmental Interpretation task, as shown below in Figure 2.9 (and confirmed by Kolmogorov-Smirnov tests; for the control group, Z = 1.00, p = .270; for the dyslexic group, Z = .509, p = .958).

Figure 2.9. Distribution of scores in suprasegmental Interpretation task



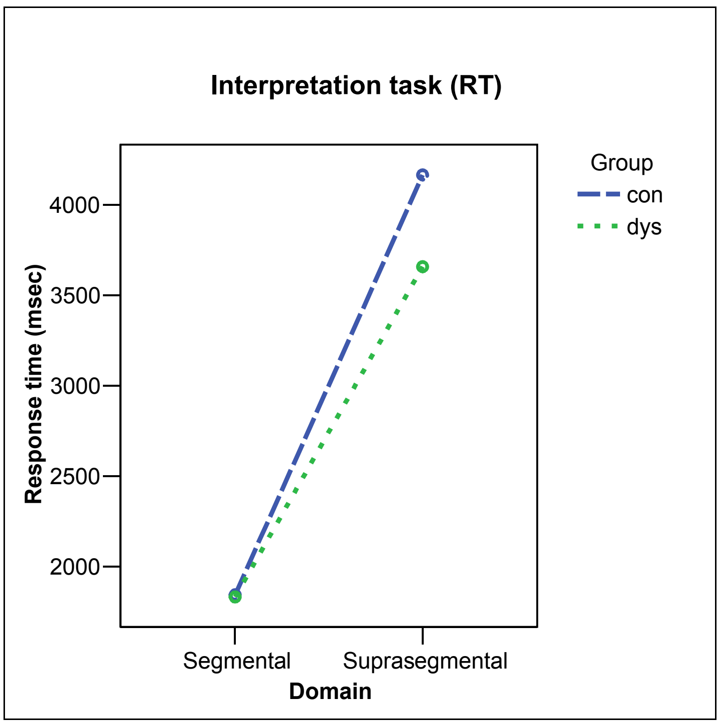
Turning now to the response time results, Table 2.5 shows the mean time taken to respond for both groups.

Table 2.5: Response time (msec) for segmental and suprasegmental versions of the Interpretation task

	Segmental version: mean (sd)	Suprasegmental version: mean (sd)
Control	1843.6 (586.5)	4164.9 (1234.5)
Dyslexic	1832.2 (425.7)	3657.5 (1130.4)

A 2x2 mixed ANOVA was run with RT as the dependent variable and the same factors as before (phonological Domain as the within-subjects independent variable, and Group as the between-subjects independent variable). There was no effect of Group ($F(1, 38) = 1.505$, $p = .227$). There was a significant main effect for Domain, with longer response times in the stress version than the segmental version ($F(1, 38) = 111.722$, $p < .001$). Although the mean response times of the dyslexic group were 507 msec shorter than those of the controls in the suprasegmental version of the task, this difference was not significant; there was no interaction between Group and Domain ($F(1, 38) = 1.598$, $p = .214$). This is shown in Figure 2.10 below.

Figure 2.10. Response times in the segmental and suprasegmental versions of the Interpretation task



2.5.2 Results of the segmental Interpretation task

Although it might have been expected that the dyslexic group would have shown weaker performance on the segmental Interpretation task relative to the control group, it was shown above (§2.5.1) that this was not the case.

The only within-items variable was the location of the contrast, i.e. whether it was word-initial or word-final. Comparing items where the contrast was word-initial (*coat/goat*) with items where the contrast was word-final (*hen/head*), there were no differences between groups or item type. Accuracy measures are shown in Table 2.6 below.

Table 2.6. Accuracy (*d'*) for items with contrasts located word-initially and word-finally in the segmental Interpretation task

	Word-initial: mean (sd)	Word-final: mean (sd)
Control	1.89 (0.10)	1.82 (0.23)
Dyslexic	1.87 (0.16)	1.82 (0.29)

A 2x2 mixed ANOVA with accuracy as the dependent variable, Contrast Location as a within-subjects independent variable, and Group as a between-subjects independent variable showed that there was no effect of Group ($F(1, 38) = 0.046$, $p = .831$), no effect of Contrast Location ($F(1, 38) = 1.912$, $p = .175$), and no interaction ($F(1, 38) = .033$, $p = .856$).

Response times are shown in Table 2.7.

Table 2.7. Response times (msec) to items with contrasts located word-initially and word-finally in the segmental Interpretation task

	Word-initial: mean (sd)	Word-final: mean (sd)
Control	1856.9 (628.0)	1830.8 (549.8)
Dyslexic	1817.4 (433.4)	1846.8 (422.0)

A 2x2 mixed ANOVA with RT as the dependent variable, Contrast Location as the within-subjects factor, and Group as the between-subjects factor showed that there was no group effect ($F(1, 38) = .005$, $p = .943$), no effect for Contrast Location ($F(1, 38) = .008$, $p = .927$), and no interaction between Group and Contrast Location ($F(1, 38) = .2.463$, $p = .125$).

2.5.3 Results of the suprasegmental Interpretation task

2.5.3.1 Comparison of performance on 'ambiguous,' 'idiomatic,' and 'filler' items

There were three different kinds of items in the suprasegmental Interpretation task: ambiguous items like *toy+factory*, idiomatic items like *hot+dog*, and filler items, like *orange juice ~ apple juice*. Although responses to the filler items were not included for the purposes of the overall comparison between the segmental and suprasegmental versions of this task (reported in §2.5.1 above), now that the suprasegmental version is being examined in detail in its own right, it is worth including the responses to the filler items as a baseline against which the responses to the ambiguous and idiomatic items can be compared.

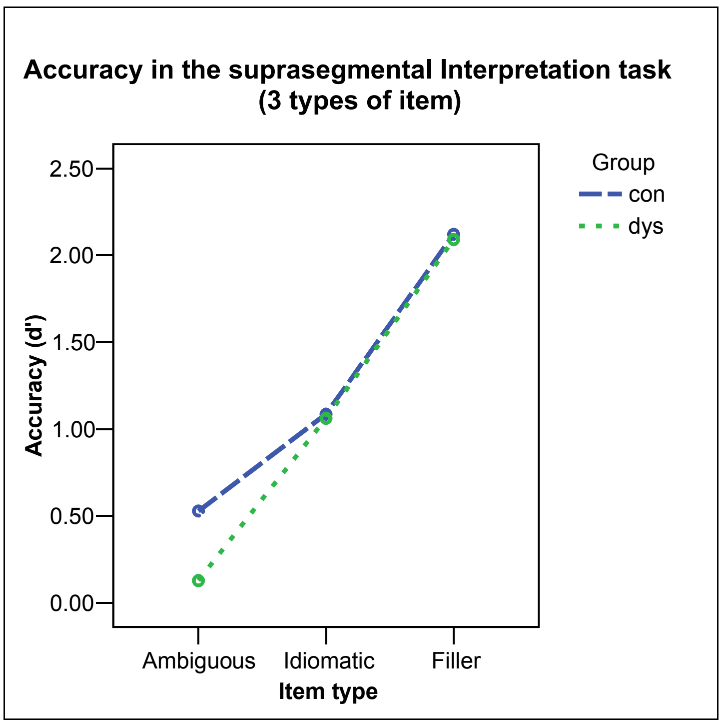
Accuracy data is shown in Table 2.8.

Table 2.8. Accuracy (*d'*) in the three types of item in the suprasegmental Interpretation task

	Ambiguous items: mean (sd)	**Idiomatic items: mean (sd)**	**Filler items: mean (sd)**
Control	0.53 (0.85)	1.09 (0.46)	2.12 (0.29)
Dyslexic	0.13 (0.75)	1.06 (0.55)	2.09 (0.29)

A 3x2 mixed ANOVA was run, with accuracy as the dependent variable, Group as the between-subjects factor and Item Type as the within-subjects factor (with three levels, corresponding to the three types of item, i.e., ambiguous, idiomatic, and filler). There was no effect of Group ($F(1, 39) = 1.461$, $p = .234$). There was a significant main effect for Item Type ($F(2, 78) = 130.934$, $p < .001$). In spite of the control group having higher accuracy than the dyslexic group in the 'ambiguous' condition, there was no significant interaction between Group and Item Type ($F(2, 78) = 1.913$, $p = .164$ using the Greenhouse-Geisser correction). See Figure 2.11.

Figure 2.11. Accuracy in the suprasegmental Interpretation task (ambiguous, idiomatic, and filler items)



It may be noted that when the filler items are excluded from the analysis the same pattern emerges: a 2x2 ANOVA with Group as the between-subjects factor and Item Type (ambiguous and idiomatic) as the within-subjects factor shows no effect for Group ($F(1, 39) = 1.512$, $p = .226$), a significant effect of Item Type, with higher accuracy in the idiomatic items ($F(1, 39) = 39.925$, $p < .001$), and no interaction between Group and Item Type ($F(1, 39) = 2.550$, $p = .118$).

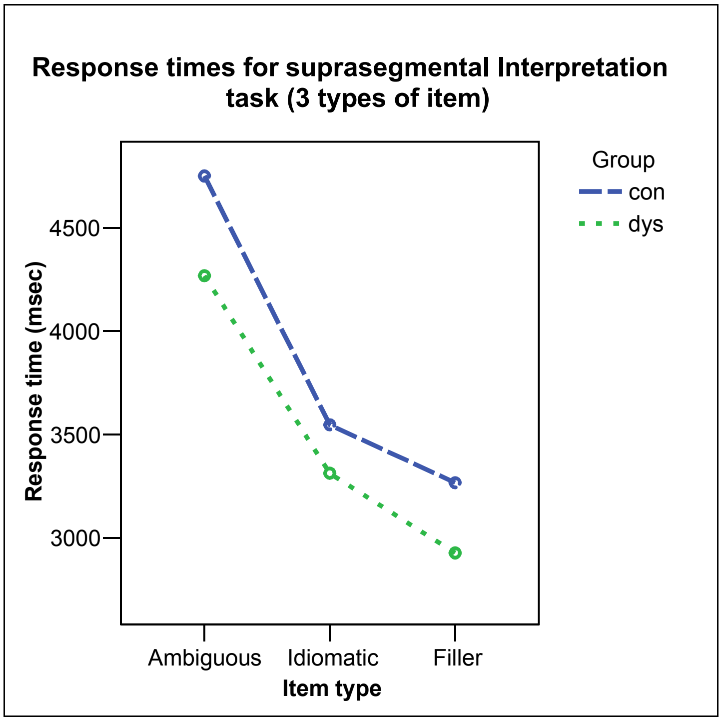
Response time data is shown in Table 2.9.

Table 2.9. Response times (msec) in the three types of item in the suprasegmental Interpretation task

	Ambiguous items: mean (sd)	**Idiomatic items: mean (sd)**	**Filler items: mean (sd)**
Control	4751.6 (1639.0)	3547.8 (895.1)	3267.5 (912.3)
Dyslexic	4268.9 (1532.6)	3313.6 (968.9)	2927.8 (813.0)

The same 3x2 mixed ANOVA was run as before, with RT as the dependent variable, Group as the between-subjects independent variable, and Item Type (ambiguous, idiomatic, filler) as the within-subjects independent variable. There was no effect of Group ($F(1, 39) = 1.387$, $p = .246$), although as may be noted (from the table and Figure 2.12 below) that the control group's response times were a few hundred milliseconds longer than those of the dyslexic group not only in the ambiguous and idiomatic conditions (by 483 msec and 234 msec respectively) but also in the filler items (by 340 msec). There was a significant main effect for Item Type ($F(2, 78) = 32.120$, $p < .001$). There was no interaction ($F(2, 78) = .229$, $p = .736$ using the Greenhouse-Geisser correction).

Figure 2.12. Response times in the suprasegmental Interpretation task (ambiguous, idiomatic, and filler items)



Again, when filler items are excluded and a 2x2 mixed ANOVA is run (Group x Item Type (ambiguous, idiomatic)), the same pattern of results emerges. There is no Group effect ($F(1, 39) = .895$, $p = .350$), there is a significant effect for Item Type, with shorter response times in the idiomatic items ($F(1, 39) = 53.300$, $p < .001$), and no interaction ($F(1, 39) = .706$, $p = .406$).

2.5.3.2 Interactions between item type and stress pattern

An analysis was also run to establish whether there was an interaction between stress pattern (compound vs phrasal) and item type (ambiguous vs idiomatic) for either group. Although Vogel and Raimy (2002) examined whether the performance of their participants varied according to the stress pattern of the stimuli, in this case, an analysis which includes item type as well as stress pattern is potentially more valuable than the straightforward comparison between stress patterns alone, as the items which were realised with compound stress in the 'idiomatic' category are real lexical items, unlike the other three kinds of item (i.e. idiomatic items with phrasal stress, ambiguous items with compound stress, and ambiguous items with phrasal stress).

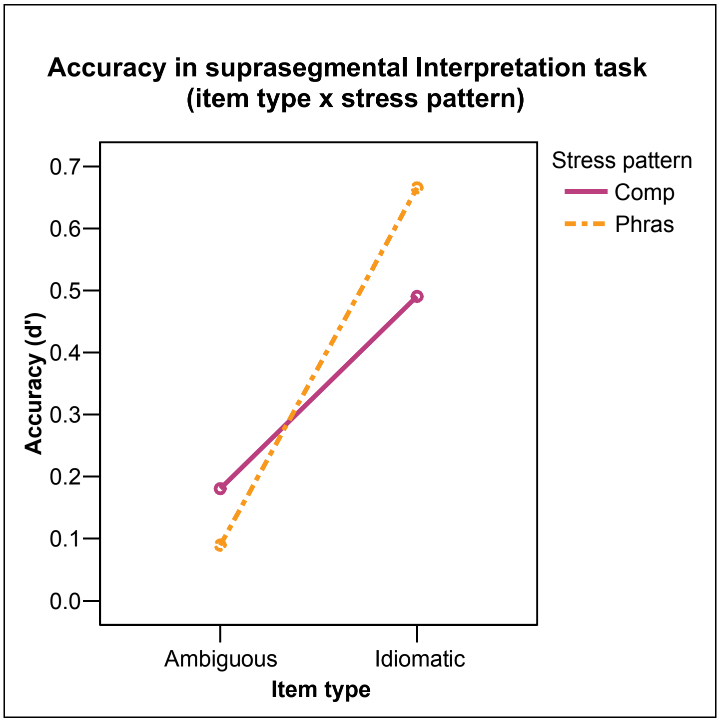
Accuracy data is shown in Table 2.10 below. Note that because of the very small number of items in some of the categories (particularly the 'ambiguous items with phrasal stress' category, which includes only 5 items in total), the majority of the *d′* calculations in this category are based on conversions of proportions of 0 and 1 according to the procedure suggested by Macmillan and Creelman (2005), mentioned above (§2.4).

Table 2.10. Accuracy (*d′*) for items with compound stress vs phrasal stress according to item type (ambiguous vs idiomatic) in the suprasegmental Interpretation task

	Ambiguous items		Idiomatic items	
	Compound stress: mean (sd)	**Phrasal stress: mean (sd)**	**Compound stress: mean (sd)**	**Phrasal stress: mean (sd)**
Control	0.38 (0.56)	0.16 (0.54)	0.54 (0.26)	0.68 (0.41)
Dyslexic	-0.02 (0.48)	0.02 (0.59)	0.44 (0.38)	0.65 (0.56)

A 2 (Item Type) x 2 (Stress Pattern) x 2 (Group) mixed ANOVA was run with accuracy as the dependent variable. As expected from the previous analyses, there was no effect for Group ($F(1, 38) = 2.555$, $p = .118$) or for Stress Pattern ($F(1, 38) = .382$, $p = .540$), and there was a significant main effect for Item Type ($F(1, 38) = 36.366$, $p < .001$). There was a significant interaction between Item Type and Stress Pattern ($F(1, 36) = 7.621$, $p = .009$). Collapsing across the groups, the interaction between Item Type and Stress Pattern is graphed in Figure 2.13 below. None of the other interactions was significant.

Figure 2.13. Accuracy in the suprasegmental Interpretation task (comparing performance on stress patterns within item types)



Response time data is shown in Table 2.11 below.

Table 2.11. Response time (msec) for items with compound stress vs phrasal stress according to item type (ambiguous vs idiomatic) in the suprasegmental Interpretation task

	Ambiguous items		Idiomatic items	
	Compound stress: mean (sd)	**Phrasal stress: mean (sd)**	**Compound stress: mean (sd)**	**Phrasal stress: mean (sd)**
Control	4695.0 (1928.7)	4656.0 (1712.3)	3493.6 (1363.9)	3521.3 (845.4)
Dyslexic	4387.7 (2047.0)	4357.1 (1475.7)	3092.5 (1024.4)	3542.1 (1070.4)

The same 2x2x2 ANOVA was run as before, this time with RT as the dependent variable (Group as the between-subjects independent variable, Item Type and Stress Pattern as within-subjects independent variables). There was no effect for Group (F(1, 34) = .356, p = .555) and no effect for Stress Pattern (F(1, 34) = .671, p = .419).

There was a significant main effect for Item Type ($F(1, 34) = 38.521$, $p = .001$), reflecting the finding reported above that the ambiguous items are harder than the idiomatic items. There was no interaction between Stress Pattern and Item Type ($F(1, 34) = .628$, $p = .434$), and no other interaction was significant.

2.6 Discussion of Interpretation results

2.6.1 Overall Interpretation results: The question of representations

The Interpretation task was intended to test representations, operationalised here as implicit knowledge of the sound patterns of language (and, in the case of the suprasegmental version of the task, the sound patterns unique to spoken language, free from any orthographic counterpart). Of all the tasks reported in this study, it is only the Interpretation task which has any real claims to be counted as a test of representations. The only skill which participants needed to have in place in order to complete it successfully was to be able to select from two options the picture which a particular word referred to, when the options which they were forced to choose from were minimally different. To the extent that phonological contrasts reflect core phonological knowledge, this task tapped into phonological knowledge. It corresponds to what Gombert (2003) calls epilinguistic skills, or “the control automatically exerted on linguistic processing by the linguistic organizations present in memory.” Epilinguistic skills, as internal or implicit comparisons which are undertaken of language material (even if it never becomes accessed or accessible to conscious inspection or manipulation), are distinguished from metalinguistic skills, which demand “real, explicit reflection on language” (Gombert 1992: 8). Metalinguistic skills are dealt with partly by the Recognition task reported in the next chapter (§3) and partly also by the manipulation tasks to be reported in the following chapters (§4 and §5), but for now the discussion is focused on the Interpretation task and the insight it gives us into the participants' representations of phonologically contrastive units.

As was reported in §2.5.1, both the control group and the dyslexic group found the segmental version of the Interpretation task easier than the suprasegmental version, but no difference was found between the two groups in this task. Irrespective of theoretical perspective, greater difficulty can be expected in the suprasegmental task, partly since the suprasegmental items are longer and more complex both phonotactically and conceptually than the familiar, concrete items with CVC structures which were used in the segmental version of the task, and partly also since the phenomenon of stress-based minimal pairs is not particularly salient to English speakers, in the sense that the existence of the contrast is not especially well known, nor does it seem to carry a large functional load in everyday conversation, and that even when the meaning difference is pointed out, naive speakers may not immediately recognise that there is a generalisation such as 'compound vs phrasal' to be made to account for the pattern.

In the remainder of this subsection, the results of the two versions of the task (segmental and suprasegmental) will be discussed in more detail, with a view to exploring the extent to which this finding may be regarded as unexpected from the perspective of the Phonological Deficit Hypothesis.

2.6.2 The segmental version of the Interpretation task

As was reported in §2.5.2, participants in both groups had overwhelmingly accurate responses to the segmental Interpretation task. Items in this task consisted of CVC words, and the within-task conditions consisted only of the location of the contrast, whether word-initial (*coat*, *goat*) or word-final (*bag*, *back*). The detailed analysis of this task showed that both word-initial and word-final contrasts were equally straightforward for both groups of participants.

It is possible that this task might have been better able to reveal differences between the control group and the dyslexic group if the words used had been more complex – if the location of the minimal difference had been inside a cluster (such as *grass*, *glass*), and/or in longer words, for example. It may also be noted that the original task as it is presented in the PALPA (Kay et al 1992) includes three pictures rather than the two which were presented in my modified version of the task. The third picture in the PALPA is of a distractor which differs from the target in two or more distinctive features (for instance, for the target *coat*, with the minimally different item *goat*, the distractor is *boat*; for the *bag*, *back* minimal pair the distractor is *bat*). Although the use of a binary choice in the present modification of the task was motivated by the need to keep the task as similar as possible to its suprasegmental counterpart (where the production of a third distractor image was prohibited by time constraints), the need to make the task more challenging could perhaps have outweighed this consideration.

As things stand, however, the ceiling effects in the dyslexic group's accuracy in the segmental version of the Interpretation task, in addition to the fact that there were no group differences in response times, mean that no firm conclusions can be drawn about whether or not the representations of segments are impaired in this group of dyslexics relative to the control group. Since the Phonological Deficit Hypothesis assumes that at least for segmental phonology, individuals with dyslexia should perform less successfully than individuals without dyslexia, the finding that performance was sufficiently accurate as not to be distinguished from that of the control group may seem unexpected. But because of the ceiling effects, it is clearly not possible to say that these results contradict this position. Rather, this task may well have been insufficiently challenging to expose any group differences which may have existed underlyingly. It may also be the case that segmental difficulties of the type that could have been uncovered by this task might be visible only in children, whereas these subjects were adults. If that is the case, we can only assume that their early segmental deficits have resolved or have been compensated for. This would then suggest that if deficits in tasks like these appear in individuals with dyslexia in childhood, such a 'representational' deficit is perhaps only a delay, rather than something disordered, in dyslexic phonology.

2.6.3 The suprasegmental version of the Interpretation task

In the suprasegmental version of this task, the dyslexic group were found to be no different from the control group in their ability to distinguish between the suprasegmental minimal pairs. In fact the response times of the dyslexic group were slightly, though non-significantly, shorter than those of the control group by a few hundred msec. Although this interaction was not statistically significant, the trend shows that their ability to distinguish between members of minimal pairs is at least no worse than that of controls – when the minimal pairs are suprasegmental. Although the results give no basis for comparison with segmental representations, they do show that the dyslexics' stress-based contrasts are unimpaired relative to those of the non-dyslexic controls.

In considering the performance of the groups in the two different kinds of minimal pair, i.e. 'genuinely ambiguous' items such as *toy+factory* and 'idiomatic' items such as *hot+dog*, it is worthwhile at this point to consider again the important differences between these types of item. It should be recalled that it is the 'genuinely ambiguous' items which are more directly useful for the purposes of this study – as is suggested by calling them genuinely ambiguous, the stress pattern is essential for distinguishing whether 'factory which produces toys' is the intended meaning rather than 'pretend factory for children to play with'. This means that it is the 'genuinely ambiguous' items which meet the criteria set out in §1.4.1, namely, that they exist independently of orthographic notation, and that they are analogous to the kinds of phonological units which have already been tested in dyslexia.[2] This is in contrast to the 'idiomatic' items, which, again as the practice of calling them 'idiomatic' is intended to convey, are identified in the first place as lexicalised compounds (with compound stress). From the class of idiomatic compounds in the lexicon, the items utilised in this task consist of the subset of these compounds which can be exploited for use in this task simply by virtue of having a sensible interpretation when they are produced with phrasal stress: there is no necessary relation (whether semantic, morphological, or syntactic) between the compound counterpart and the phrasal counterpart. This is an entirely pragmatic and opportunistic use of this particular idiosyncratic property of these English idioms. It also entails that the 'idiomatic' items fail to fully meet the criteria set out in §1.4.1: they *can* (although optionally and often inconsistently) be distinguished orthographically (by means of hyphenation and spacing), and their link to the lexicon (in the case of the compounds) means that they are not analogous to phonological units such as phonemes in the same way as the 'genuinely ambiguous' items are.

The primary implication of this difference in the nature of the items is as follows. On the one hand, semantic representations for the 'genuinely ambiguous' items needed to be constructed from scratch, regardless of whether the auditory stimulus had compound stress or phrasal stress, as these items are the result of productive and semantically transparent processes. On the other hand, every time a participant heard *an 'idiomatic' item produced with compound stress*, they were hearing a real

[2] See also the discussion of 'quasi-phonemic' contrasts in Chapter 1, §1.4.2, for details of how exactly these minimal pairs are and are not analogous to conventional segmental minimal pairs.

lexical item, with (by definition) a non-transparent meaning, which must be listed in the lexicon. These particular auditory stimuli differ therefore both from their own corresponding phrases and also both the compound and phrasal counterparts of the 'genuinely ambiguous' items.

There are two possible ways in which this could relate to the Phonological Deficit Hypothesis for dyslexia. Firstly, the rationale which led to the identification of the genuinely ambiguous items can be applied. In this case, for testing the Phonological Deficit Hypothesis it may only be necessary to examine the behaviour of the two groups of participants in the genuinely ambiguous items – these are the items which give the best insight into implicit knowledge of spoken-language-specific sound patterns (i.e. patterns entirely independent of orthography, bearing in mind that the distinction between the 'idiomatic' items such as *'hotdog* and *hot 'dog* can optionally be made through spacing and/or hyphenation in written form). Since the dyslexic group did not differ from the control group either in accuracy or response times on these items, it can be argued that the implicit knowledge which these dyslexic participants have of the sound patterns specific to spoken language is unimpaired, and that their phonological representations (for at least this kind of phonologically contrasting units) are intact.

On the other hand, however, because the compounds in the 'idiomatic' category are lexical items, it is possible to construe these particular items as more relevant to the Phonological Deficit Hypothesis than the other kinds of item in this task. Under this view, if representations are impaired, it should be expected that the dyslexic group would show a deficit in the idiomatic items with compound stress. This was not borne out in the results, however: when the data was analysed for interactions between item type (ambiguous, idiomatic) and stress pattern (compound stress, phrasal stress), there was no effect or interaction involving the groups of participants, either in the accuracy of responses or time taken to respond (§2.5.3). Indeed, although both groups had higher accuracy in the idiomatic items than in the ambiguous items, their accuracy was significantly higher in idiomatic items with *phrasal* stress than those with compound stress. Although this indicates that items in the lexicon were treated differently from items that are not in the lexicon, their lexical status did not make them easier to match with their pictorial interpretation than non-lexical items, and, more importantly for present purposes, they did not elicit different performance from the dyslexic group compared to the control group.

A final point may be made about the materials of the suprasegmental Interpretation task by way of conclusion, and specifically the visual materials. Although it was known from the pilot study (§1.4) that the pictures were suitable for the task (and anecdotally, when participants said that they found the task difficult, they reported that the difficulty was with deciding what the auditory stimulus referred to, as the pictures were sufficiently clear in what they were intended to represent), if the task was to be used again, there would be scope for making improvements to the visual images. Specifically, the images are rather detailed and the colouring of some of them is fairly subtle. It would be important to establish if any of the picture pairs used in the current study were particularly difficult, and whether performance could be improved by changing the pictorial options. Reaction times would perhaps be reduced if the pictures were less complex in terms of detail and colouring, and if trialling the pictures allowed modifications to be made to make the intended meanings of the pictures as transparent as possible.

2.7 Relation of Interpretation performance to literacy measures

In this section, the relationships which hold between the literacy skills of the two groups of participants and their performance in the Interpretation task are examined. Literacy skills were measured by the Reading and Spelling subtasks of the WRAT, as outlined in §2.3, and performance in the Interpretation task is measured both in terms of accuracy and response time. Due to the ceiling effect in the segmental version of the Interpretation task, the analysis presented here includes data from the suprasegmental version alone. The results of the analysis are presented in §2.7.1, for the two groups of participants separately, the control group first, followed by the dyslexic group. The correlations are then discussed in §2.7.2.

2.7.1 Correlations of Interpretation performance and WRAT scores

2.7.1.1 Results for the control group

Table 2.12 shows the Pearson correlation coefficients for the two WRAT subtasks with both measures of suprasegmental Interpretation performance. Note that the table includes both accuracy and response time data together.

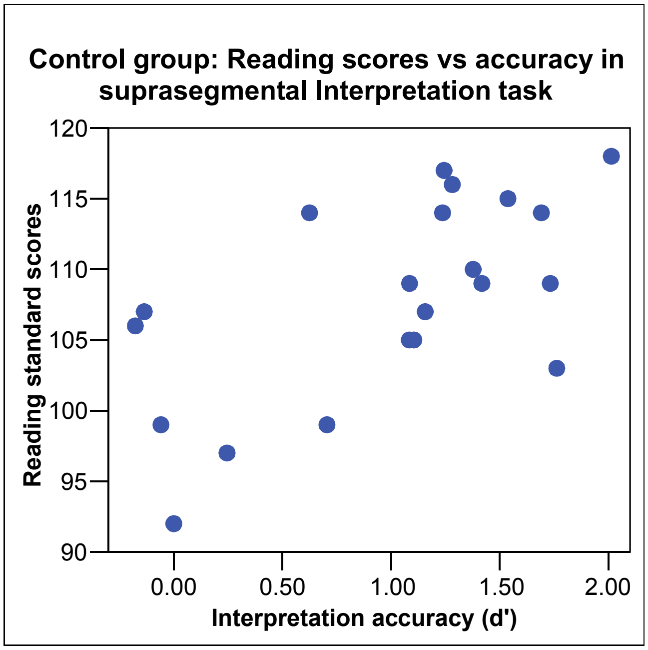
Table 2.12. Correlation of controls' WRAT Reading and Spelling standard scores with performance (accuracy and response times) in the suprasegmental Interpretation task

	WRAT Reading	**WRAT Spelling**
Suprasegmental Interpretation accuracy (d')	r = .622 ** p = .003 n = 21	r = -.120 p = .605 n = 21
Suprasegmental Interpretation response time (msec)	r = -.044 p = .851 n = 21	r = .231 p = .315 n = 21

It can be seen from the table that there was a strong correlation between the control group's accuracy in the suprasegmental Interpretation task and their WRAT

Reading standard scores, with higher accuracy associated with higher Reading scores. This is shown in Figure 2.14.

Figure 2.14. Control group's WRAT Reading scores against suprasegmental Interpretation accuracy



2.7.1.2 Results for the dyslexic group

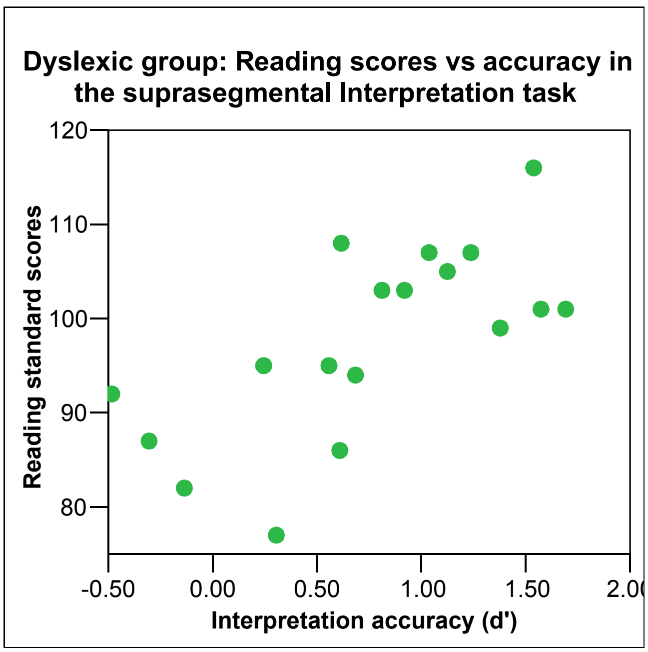
For the dyslexic group, accuracy on the suprasegmental Interpretation task is also significantly correlated with WRAT Reading, with higher accuracy scores associated with higher Reading scores (r = .689, p = .002), but there are no other significant correlations in their data. The correlation coefficients are shown in Table 2.13, which again shows both accuracy and response time data.

Table 2.13. Correlation of dyslexics' WRAT Reading and Spelling standard scores with performance (accuracy and response time) in the suprasegmental Interpretation task

	WRAT Reading	WRAT Spelling
Suprasegmental Interpretation accuracy (*d'*)	*r* = .689 ** *p* = .002 *n* = 18	*r* = .331 *p* = .179 *n* = 18
Suprasegmental Interpretation response time (msec)	*r* = -.388 *p* = .111 *n* = 18	*r* = -.363 *p* = .139 *n* = 18

The dyslexic group's accuracy values and Reading scores are plotted in Figure 2.15.

Figure 2.15. Dyslexic group's WRAT Reading scores against suprasegmental Interpretation accuracy



2.7.2 Discussion of the relationship between the Interpretation task and literacy measures

Any interpretation of the correlations needs to be sensitive to the fact that finding a correlation is not conclusive evidence for any of the theoretical positions which have been discussed so far, although, on the other hand, the absence of any relationship between literacy and performance on this task would be damaging at least to the Phonological Deficit Hypothesis. Furthermore, although a relationship has been found between literacy and performance on this task, this relationship holds with the suprasegmental version of the task, rather than the segmental version (necessarily, since segmental Interpretation performance was at ceiling for the dyslexic group). This clearly limits the implications which can be drawn from the findings, since the results are not fully informative in the absence of correlations with performance on the segmental version of the task. In a hypothetical case where this measure of segmental representations was not correlated with measures of literacy ability, for example, it would become difficult to claim that the quality of segmental representations is causally connected with an individual's literacy skills – but since no segmental data is available, it is impossible to speculate any further on this point.

The data that is available is from the suprasegmental version of the task, and it was found that the accuracy of both the control group and the dyslexic group in the suprasegmental Interpretation task was strongly correlated with their respective WRAT Reading scores, with higher Reading scores associated with higher suprasegmental Interpretation accuracy. This shows that there is some relationship between the ability to distinguish between the alternative meanings for stress-based minimal pairs and the single word decoding abilities measured by the Reading subtest of the WRAT. However, this finding on its own does not indicate the precise nature of the relationship. Although it is consistent with the 'broad' reading of the Phonological Deficit Hypothesis (the position which suggests that both segmental and suprasegmental representations are impaired in dyslexia and that this impairment is the source of dyslexic individuals' reading difficulties), it does not provide direct support for either the 'narrower' reading of the Phonological Deficit Hypothesis (that only segmental representations are impaired), nor the view expressed in Chapter 1 that it is not representations so much as metalinguistic skills which are relevant for reading acquisition and success. Yet these two positions can nevertheless accommodate this finding, which is reminiscent of the findings of Whalley and Hansen (2006), reviewed in §1.3.4 in the previous chapter. Whalley and Hansen showed that for 9 year old typically developing children, the ability to use prosody to distinguish between *chocolate, cake, and honey*, and *chocolate cake and honey* was most strongly associated with word identification performance. As was pointed out in Chapter 1, there is a consensus that global spoken language skills are related to reading development even when they have no bearing on the setting up of grapheme-phoneme correspondences in the sense in which the Phonological Deficit Hypothesis invokes it.

2.8 Conclusions arising from the Interpretation task

In this chapter, it was investigated whether or not a group of individuals with dyslexia differed from a group of comparable individuals with no history of dyslexia on a task in which they were required to assign the correct meaning to a particular auditory word or phrase, when they had to differentiate between the stimulus and its minimally different counterpart (*coat* rather than *goat*, and *'toy factory* rather than *toy 'factory*).

This task was originally designed with a view to teasing apart the role played by orthographic knowledge from the role of knowledge specific to spoken language, in order to be able to have something to say about phonological representations which was not confounded by contributions from orthographic knowledge, something which should be seen as essential in the context of populations which are known to have difficulties with literacy, in the light of the mutually reinforcing relationship between phonological segments and alphabetic symbols. This concern arose from the argument presented in Chapter 1, where it was also hypothesised that, rather than involving an impairment of phonological representations as such, the phonological deficit in dyslexia may need to be identified instead as a deficit in the application of metalinguistic analysis to the sound patterns of spoken language. The prediction which was derived from this argument is that when orthographic influences are excluded from a task which taps implicit phonological knowledge, individuals with dyslexia should not show any deficit. This prediction is somewhat different from that which arises from the Phonological Deficit Hypothesis. As was shown in Chapter 1, the central claim of the Phonological Deficit Hypothesis, that phonological representations are impaired in dyslexia, can be interpreted in both a broad sense and a narrow sense. In the broad sense, it can be read as a claim that all phonological representations, whether segmental or suprasegmental, are impaired in dyslexia. Under this interpretation, a deficit was expected in both the segmental and suprasegmental versions of the Interpretation task. In the narrow sense, though, it can be read as a claim that only segmental phonological representations are impaired. Under this interpretation, a deficit should have been seen only in the segmental versions of the Interpretation task (with performance in the suprasegmental version on a par with that of the control group).

However, as the results showed, the segmental version of this task did not differentiate between the groups, and indeed it was easy enough that the accuracy rates of both groups were very high (for the dyslexic group, at ceiling level). Some suggestions were made in the discussion as to how this version of the task could be made more challenging to the participants, and so more likely to uncover any deficits which may characterise one group of participants (§2.6). However, any discussion of how the performance of the two groups compares in areas of phonology which are and are not supported by orthography clearly relies on having a body of evidence for their segmental phonological skills, and this was not provided by the tasks reported in this chapter.

With this in mind, the main implication which can be drawn from the results of the suprasegmental tasks is that there is no evidence that orthography-free areas of phonological representations are impaired in this group of individuals with dyslexia. This result also fails to support the broader interpretation of the Phonological Deficit Hypothesis, in that it shows that non-segmental areas of phonology are not impaired, although it is consistent with the narrower interpretation (that only segmental phonological representations are impaired in dyslexia).

Having looked at these measures of phonological *representations*, the next step is to investigate phonological awareness, or the application in metalinguistic analysis and computation of putative underlying representations. In the next few chapters, phonological awareness will be investigated from two different angles – leaving the question of manipulation skills to Chapters 4 and 5, Chapter 3 will explore the phonological awareness of this group of individuals with dyslexia in the sense of the ability to undertake basic metalinguistic analysis of spoken language.

Chapter 3

The Recognition task

3.1 Introduction

The task reported in this chapter is the Recognition task, which aimed to test how well participants could recognise a particular phonological unit, when it is presented alongside its minimally different counterpart. In this task the meaning of the word or phrase was not relevant to the task demands, and participants were instead required to undertake a basic metalinguistic analysis of the stimulus by attending to some aspect of the auditory form of the word.

Like the Interpretation task, the Recognition task consisted of both a segmental and a suprasegmental version. As this is a metalinguistic task, which calls on an aspect of phonological awareness, the prediction of the Phonological Deficit Hypothesis is that a deficit should be seen in individuals with dyslexia relative to controls. This prediction is particularly clear in the case of the segmental version of this task, as it is uncontroversial in the literature that phonemic phonological awareness is impaired in dyslexia. In the case of the suprasegmental version, the absence of any orthographic counterpart for stress-based contrasts means that participants can be asked to make the same metalinguistic judgments on suprasegmental minimal pairs without any input from orthographic knowledge. Again the Phonological Deficit

Hypothesis makes no explicit comment on whether metalinguistic awareness of suprasegmental aspects of phonology is expected to be impaired over and above the awareness of segmental aspects: taken in the broad sense, where both segmental and suprasegmental phonological representations are assumed to be impaired, the Phonological Deficit Hypothesis does predict an impairment in suprasegmental awareness, while taken in the narrower sense it does not predict a suprasegmental metalinguistic deficit (i.e., if only segmental phonological representations are impaired, a deficit in segmental phonological awareness can be predicted, but a deficit in suprasegmental phonological awareness cannot be produced by a deficit in segmental phonological representations). From the perspective of the Metalinguistic Hypothesis put forward in Chapter 1, individuals with dyslexia are clearly expected to show a deficit relative to controls in both the segmental and the suprasegmental versions of the Recognition task.

In this chapter the materials for the Recognition task are first presented, followed by the participants and the experimental procedure. The results are presented in §3.5, following the same format as in the previous chapter, with the overall results of comparing the segmental and suprasegmental versions first, followed by a closer examination of the two versions separately. A discussion of these results is then provided in §3.6.

As was previously done in Chapter 2, §3.7 presents the results of testing whether there is any relationship between performance on the Recognition task and literacy abilities as measured by the WRAT, for either group. It was argued in Chapter 1 that the skill of metaphonological analysis is more important than the nature of underlying representations for successful literacy acquisition, and it has frequently been shown in the literature that various measures of phonological skills correlate significantly with measures of literacy ability. Since the tasks in the present study have been designed not only to measure phonological skills in a slightly different way from how it has been done in other studies, and also with a view to isolating basic metalinguistic skill from more complex applications of metalinguistic skills (as in the manipulation tasks, to be reported in the following chapters), it is important to see whether the particular phonology-related skills tested in the present study are also associated with literacy measures. Again, although it will be problematic for both the view proposed in Chapter 1 and also the Phonological Deficit Hypothesis if no relationship is found between these measures, if it is established that some relationship holds, this will need to be interpreted carefully. A discussion of the correlation results will be provided in §3.7.2.

Finally for this chapter, some concluding comments will be made in §3.8, summarising what has been found up to this point, and prospecting forward to the tasks reported in the following two chapters.

3.2 Recognition task materials

3.2.1 Materials for segmental Recognition task

The segmental version of the Recognition task consisted of 24 minimal pairs, half of which were pairs involving /s/ and half involving /t/ (e.g. the pair *fussy* and *fuzzy* in the /s/ list, or *sonnet* and *sonic* in the /t/ list). These phonemes were selected arbitrarily from the classes of fricatives and voiceless stops. All the items were bisyllabic and the contrasts were located either word-medially (*fussy*, *fuzzy*), word-finally (*release*, *relief*), or in a consonant cluster (e.g. *slipper*, *flipper*).[1] Some studies have suggested that identifying consonants within clusters is more difficult than

[1] Note that in the ‘cluster’ items, although the target segment is located in a tauto-syllabic cluster (as identified by applying the maximal onset principle), the segment which its minimal pair is based on may not always be itself belong to the same syllable as its adjacent consonant. This applies to the pairs /l□.stŮd/, /l□f.tŮd/, and /må.ste/, /måf.te/.

identifying singleton consonants for individuals with dyslexia (e.g. Fawcett and Nicolson 1995). In the light of several studies which have demonstrated that material located at the beginning of words can facilitate word recognition and lexical retrieval, e.g. Nooteboom (1981) and those mentioned by Beckman (1997), none of the contrasts in this list of stimuli were located word-initially. The complete stimulus list is provided in Appendix C.

Each word was read aloud in isolation from a list so as to avoid the contrasts being made explicitly, and the recorded words were sorted into pairs subsequently. Auditory instructions specifying the phoneme which the participants should identify were also recorded; these instructions were read by the same speaker as read the stimuli. The selected speaker for this task was a female native speaker of Scottish English who was phonetically trained as a qualified speech and language therapist.

3.2.2 Materials for suprasegmental Recognition task

The suprasegmental version of this task consisted of 20 stress-based minimal pairs, none of which were the same as those used in the Interpretation task. They included 12 items of the 'genuinely ambiguous' type (e.g. *steel warehouse*) and 8 of the 'idiomatic' type (e.g. *blackbird*). These are referred to as 'true minimal pairs', to distinguish them from the other items in this task, namely 20 near minimal pairs (e.g. *briefcase ~ brief chase*, and *pickpocket ~ back pocket*). The complete stimulus list is provided in Appendix C.

The items were read by the speakers in isolation in their pairs, i.e. in the same procedure as outlined for the stress-based Interpretation task. The selected speaker for this task was a female native speaker of Scottish English who was phonetically trained as a qualified speech and language therapist, i.e. the same speaker as was selected for the segmental version of this task.

Acoustic analysis of the true minimal pairs showed that the speaker produced clear differences between the compound readings and the phrasal readings in both pitch and duration. Table 3.1 shows values for the pitch peaks and the duration of the lexically stressed syllable in each element of the sequence.

Table 3.1. Pitch (Hz) and duration (msec) in suprasegmental Recognition materials

	Word1 (e.g. *steel*)		**Word2 (e.g. *warehouse*)**	
	Pitch: mean (sd)	**Duration: mean (sd)**	**Pitch: mean (sd)**	**Duration: mean (sd)**
Compound	235.5 (34.8)	330.5 (91.7)	174.1 (15.8)	450.0 (182.1)
Phrasal	188.6 (17.1)	381.6 (104.5)	195.14 (14.1)	492.5 (198.6)

Pitch in Word1 of compounds was significantly higher than that of phrases (paired $t(22) = 7.945$, two-tailed $p < .001$), while pitch in Word2 of phrases was significantly higher than that of compounds (paired $t(22) = 5.417$, two-tailed $p < .001$). The duration of the stressed syllable of both components of phrases was significantly longer than that of compounds (for Word1, paired $t(22) = 3.601$, two-tailed $p = .002$; for Word2, paired $t(22) = 2.934$, $p = .008$). In sum, compounds had higher pitch in Word1 than phrases and the lexically stressed syllable in both elements of the compounds was shorter in duration than for the phrases.

As in the previous chapter, the following table (Table 3.2) provides descriptive values for the items which were selected from each pair to be presented to participants, showing the values for the ambiguous and idiomatic minimal pairs separately. Again, ranges are provided rather than standard deviations as the number of items in each category is relatively small. There were 7 ambiguous items with compound stress and 5 with phrasal stress, 3 idiomatic items with compound stress and 5 with phrasal stress.

Table 3.2. Pitch (Hz) and duration (msec) of suprasegmental Recognition materials, showing ambiguous and idiomatic items separately

	Word1 (e.g. *steel* or *black*)		**Word2 (e.g. *warehouse* or *bird*)**	
	Pitch: mean (range)	**Duration: mean (range)**	**Pitch: mean (range)**	**Duration: mean (range)**
Ambiguous Compound	239.5 (189.6-288.6)	308.6 (193.5-596.0)	165.5 (150.4-179.5)	433.8 (250.8-692.0)
Idiomatic Compound	214.9 (182.7-171.5)	365.0 (316.0-400.0)	180.5 (171.5-189.7)	624.0 (495.0-728.0)
Ambiguous Phrase	184.8 (177.4-197.3)	442.5 (305.6-610.0)	203.8 (185.6-217.2)	417.1 (212.5-756.0)
Idiomatic Phrase	183.2 (171.0-192.3)	392.0 (325.0-431.0)	198.9 (176.0-209.8)	485.3 (164.4-663.0)

3.3 Participants

The individuals who took part in the Recognition task are the same as those who took part in the Interpretation task, as described in Chapter 2 (§2.3) (and see also Appendix A).

The decision was taken to test the same individuals on all four of the tasks reported in the present study primarily in order to establish whether individuals who may show deficits in segmental manipulation tasks will also show a deficit in suprasegmental manipulation tasks and/or a deficit in tests of representations. Although retaining the same participants for all tasks raises some considerations in terms of the generalisability of the results (and this will be discussed further in §6), it was felt that the advantages in terms of the insight the results would provide into the relationships between the phonology-related skills of the same individuals would outweigh these considerations in this exploratory phase. (That is, it is the connection between metalinguistic and manipulation skills on the one hand, and representations on the other hand (in terms of both segmental and suprasegmental areas of phonology) which is of primary interest in the present study, necessitating the investigation of these phonology-related skills in the same individuals.)

3.4 Procedure for Recognition task

As described in §2.4, participants were tested individually, and the order of presentation was varied so that they either took part in both versions of the Recognition task after completing both versions of the Interpretation task, or else in the order of both segmental tasks prior to both suprasegmental tasks.

In both versions of the Recognition task, participants were given pre-recorded auditory instructions as to what particular sound they were to listen for, and they were encouraged to listen to the instructions again if they missed the target sound on the first hearing. In the segmental version, to monitor for /s/, the auditory instructions were: "Think about the first sound in the word *sing*. It's the same as the first sound in the word *soft*. Now listen for this sound in the words which follow." The instructions to monitor for /t/ used the examples *ten* and *time*. Examples were also provided verbally by the experimenter prior to the task using 'the first sound in the words *man* and *meat*.' None of the examples (nor the target sounds) were presented in written form in the on-screen instructions. In the suprasegmental version, it was explicitly pointed out to participants that the difference between *hotdog* and *hot dog* was in the way that they were stressed – there was both the *'hotdog* pattern, or the DA-da pattern, and the *hot 'dog*, or da-DA, pattern. The target was then identified to the participant both by label (e.g. 'the da-DA pattern') and a sample sound (e.g. *black 'bird*).

The different target sounds in the Recognition task were presented in separate lists (i.e. the items containing target /t/ were presented in a separate list from the items containing target /s/, and similarly the items where the target to be identified was compound stress were presented in a separate list from the items where the target was phrasal stress). Each participant heard both lists for both versions of the task. The order of list presentation was randomised for each participant, as well as the order of items within each list.

On each trial participants heard two items – one containing the target sound (phoneme or stress pattern) and the other consisting of its minimally different counterpart. Participants were required to state whether the target sound occurred in the first presented item or the second (e.g. whether /s/ occurred in *fussy* or *fuzzy*, or whether end-stress occurred in *hotdog* or *hot dog*). Using the same response keys as before, they made their choice in response to a screen containing the number "1" on the left hand side of the screen and "2" on the right hand side, to represent the first and second items in the sequence of presented items respectively. As described earlier (§2.4) participants were encouraged to use the forefinger of each hand to press the keys. The target segment was located in the first word and in the second word equally often (i.e., "1" was the correct response as often as "2"). There was an interval of 500msec between the two members of each pair.

As before, the Recognition task was presented using E-Prime (Psychology Software Tools, Pittsburgh, PA).

3.5 Results of the Recognition task

As in the previous task, both accuracy and reaction time data were collected for each participant.

Accuracy was again measured using the formula for *d′* which is appropriate for two-alternative forced choice tasks, as described in Chapter 2 (Macmillan & Creelman 2005). The same procedure was used as before for dealing with proportions of 0 and 1 in the calculation of *d′* (see §2.5).

Reaction time was measured in milliseconds, for correct responses only. For each individual participant, response times which were longer or shorter than 2 standard deviations from their mean response time were discarded, as were the corresponding choices.

3.5.1 Overall results of the Recognition task

This task aimed to test how well participants could listen to the auditory form of a word, excluding its meaning, so as to identify particular phonological units – either a given phoneme (does /s/ occur in *fussy* or *fuzzy*?) or a given stress pattern (does end-stress occur in *steel ˈwarehouse* or *ˈsteel warehouse*?).

Note that although the stimuli in the suprasegmental version consisted of both minimal pairs and near minimal pairs, only the true minimal pairs were included in this analysis (i.e. data from the near minimal pairs was not included here, although it will be presented in §3.5.3 below, where the results of the suprasegmental version are examined in detail).

Table 3.3 shows the mean accuracy (*d'*) for both groups in the two versions of the Recognition task. For information, accuracy rates expressed as percentages of correct responses were 95.0% and 86.3% in the segmental version of this task for the control group and the dyslexic group respectively, and 66.0% and 64.3% respectively in the suprasegmental version.[2]

Table 3.3. Accuracy (*d'*) for segmental and suprasegmental versions of the Recognition task

	Segmental version: mean (sd)	**Suprasegmental version: mean (sd)**
Control	2.10 (0.29)	0.80 (0.94)
Dyslexic	2.01 (0.34)	0.72 (0.53)

A 2x2 mixed ANOVA was carried out with accuracy as the dependent variable, phonological Domain as the within-subjects factor, and Group as the between-subjects factor. There was no effect for Group ($F(1, 38) = .427$, $p = .517$). There was a significant main effect for Domain, with lower accuracy in the stress version than the phoneme version ($F(1, 39) = 103.327$, $p < .001$). There was no interaction ($F(1, 39) = .001$, $p = .970$). See Figure 3.1.

[2] Note that although the accuracy of both groups is high in the segmental version of this task, Kolmogorov-Smirnov tests show that the data is normally distributed (both for the two groups and in both versions of the task).

Figure 3.1. Accuracy in the segmental and suprasegmental versions of the Recognition task

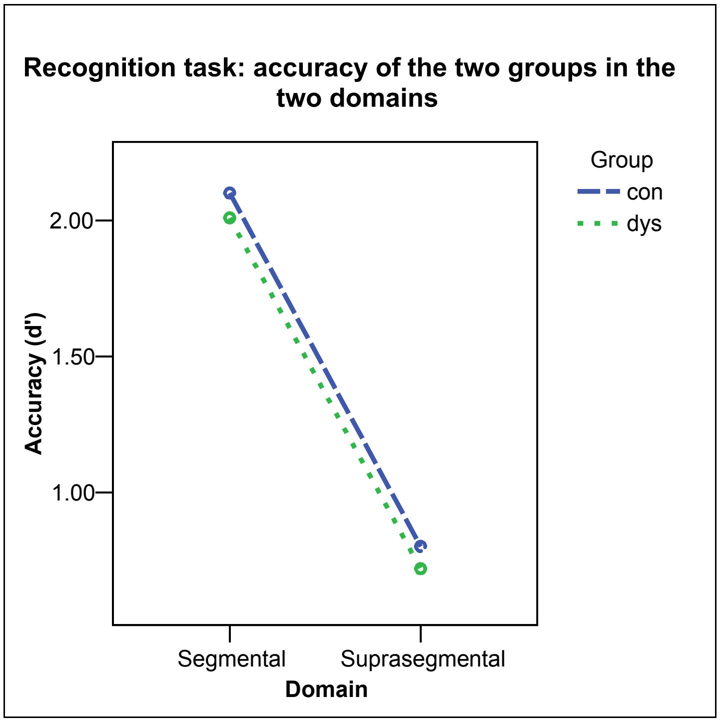


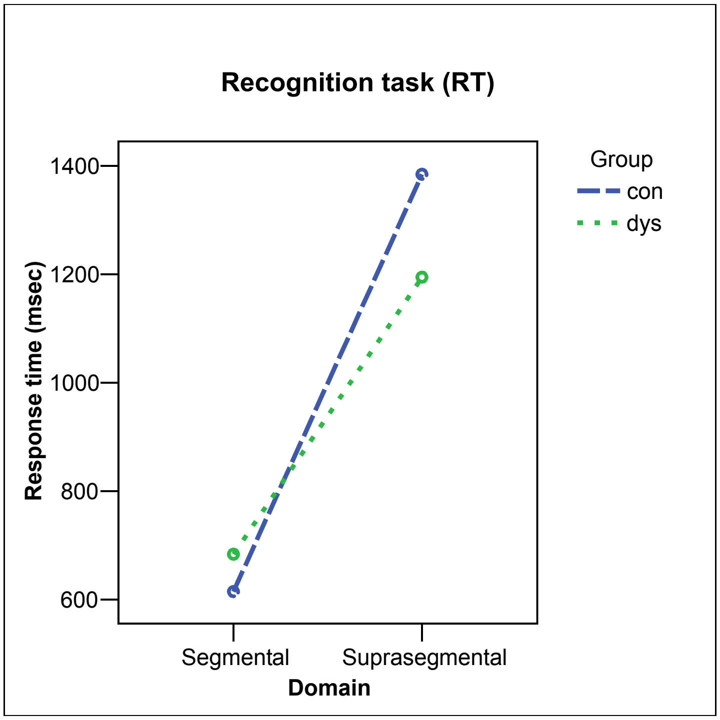
Table 3.4 shows the mean response times for both groups in the Recognition task.

Table 3.4. Response times (msec) for segmental and suprasegmental versions of the Recognition task

	Segmental version: mean (sd)	Suprasegmental version: mean (sd)
Control	614.8 (288.1)	1384.0 (636.1)
Dyslexic	683.8 (668.4)	1194.4 (592.7)

A 2x2 mixed ANOVA was carried out with RT as the dependent variable, phonological Domain as the within-subjects factor, and Group as the between-subjects factor. There was no effect for Group ($F(1, 39) = .222$, $p = .640$). There was a significant main effect for Domain, with longer reaction times in the suprasegmental version than the segmental version ($F(1, 39) = 27.713$, $p < .001$). Although the dyslexic group was on average 190 msec faster to respond than the control group in the suprasegmental items, the interaction between Group and Domain was not significant ($F(1, 39) = 1.131$, $p = .294$).

Figure 3.2. Response times in the segmental and suprasegmental versions of the Recognition task



3.5.2 Results of the segmental Recognition task

3.5.2.1 Singletons vs clusters

In the light of studies such as that of Fawcett and Nicolson (1995) which suggest that individuals with dyslexia have difficulty segmenting clusters into singleton consonants, it was of interest to examine the performance of the groups in the singleton items in comparison with the cluster items in the present study. One third of the items had the target phoneme located in a cluster, while in the remainder of the items the target was a singleton consonant located either intervocalically or word-finally.

Accuracy means are shown in Table 3.5.

Table 3.5. Accuracy (*d'*) for singleton targets vs targets in a cluster in the segmental Recognition task

	Singleton targets: mean (sd)	Targets in a cluster: mean (sd)
Control	1.98 (0.28)	1.31 (0.26)
Dyslexic	1.89 (0.27)	1.23 (0.24)

A 2x2 mixed ANOVA with accuracy as the dependent variable, Item Type as the within-subjects independent variable and Group as the between-subjects independent variable showed that there was no effect for Group ($F(1, 40) = 1.683$, $p = .202$), but there was a significant main effect for Item Type, with lower accuracy in the cluster items ($F(1, 40) = 172.595$, $p < .001$). There was no interaction ($F(1, 40) = .039$, $p = .844$).

Response times are shown in Table 3.6.

Table 3.6. Response time (msec) for singleton targets vs targets in a cluster in the segmental Recognition task

	Singleton targets: mean (sd)	Targets in a cluster: mean (sd)
Control	580.1 (272.5)	690.6 (372.0)
Dyslexic	680.3 (696.7)	776.3 (610.4)

The same 2x2 mixed ANOVA as was run as before, but with RT as the dependent variable (Item Type as the within-subjects independent variable and Group as the between-subjects independent variable). Again, while there was no main effect for Group ($F(1, 40) = .355$, $p = .554$), there was a significant main effect for Item Type, with longer response times in the items with clusters ($F(1, 40) = 8.882$, $p = .005$). There was no interaction ($F(1, 40) = .044$, $p = .835$).

3.5.3 Results of the suprasegmental Recognition task

As outlined in the Materials section (§3.2.2 above), the suprasegmental version of the Recognition task included two kinds of true minimal pairs (as well as near minimal pairs such as *brief case ~ brief chase*). The two kinds of true minimal pair are the same as those used in the previous chapter: genuinely ambiguous items such as *steel warehouse*, and idiomatic compounds such as *black bird*. In parallel with the suprasegmental Interpretation task, it will be investigated whether performance in these two kinds of item differed depending on the stress patterns (compound vs phrasal stress).

3.5.3.1 Interactions between item type and stress pattern

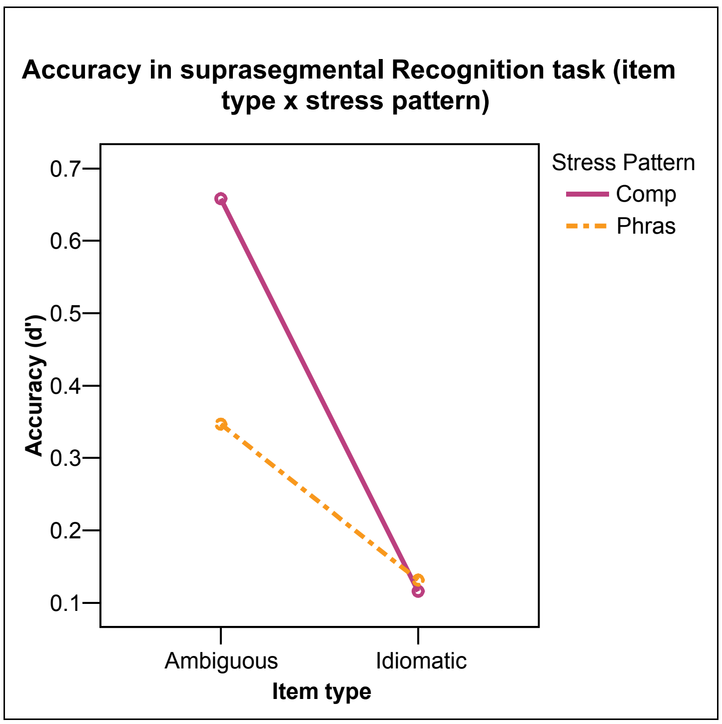
Accuracy data is shown in Table 3.7 below. As in §2.4, the low numbers of observations from which *d′* could be calculated should again be noted; in several of the data cells, the conversions suggested by Macmillan and Creelman were used in order to avoid proportions of 0 and 1 in calculating *d′*.

Table 3.7. Accuracy (*d′*) for items with compound stress vs phrasal stress according to item type (ambiguous vs idiomatic) in the suprasegmental Recognition task

	Ambiguous items		**Idiomatic items**	
	Compound stress: mean (sd)	**Phrasal stress: mean (sd)**	**Compound stress: mean (sd)**	**Phrasal stress: mean (sd)**
Control	0.70 (0.68)	0.38 (0.37)	0.18 (0.38)	0.03 (0.64)
Dyslexic	0.62 (0.61)	0.32 (0.46)	0.05 (0.36)	0.23 (0.43)

A 2 (Item Type) x 2 (Stress Pattern) x 2 (Group) mixed ANOVA was run with accuracy as the dependent variable. There was no effect for Group ($F(1, 32) = .030$, $p = .863$). There was a significant main effect for Item Type, with lower accuracy in the idiomatic items than in the ambiguous items ($F(1, 32) = 56.854$, $p < .001$). There was no effect for Stress Pattern ($F(1, 32) = 2.413$, $p = .130$). The interaction between Item Type and Stress Pattern was nearly significant ($F(1, 32) = 3.461$, $p = .072$). See Figure 3.3. No other interaction was significant.

Figure 3.3. Accuracy in the suprasegmental Recognition task (comparing performance on stress patterns within item types)



Response time data is shown in Table 3.8 below.

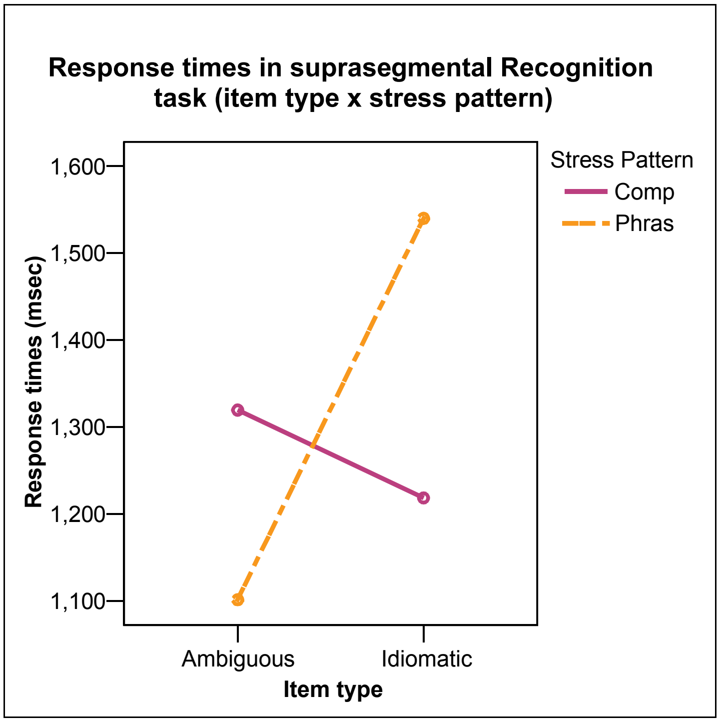
Table 3.8. Response time (msec) for items with compound stress vs phrasal stress according to item type (ambiguous vs idiomatic) in the suprasegmental Recognition task

	Ambiguous items		**Idiomatic items**	
	Compound stress: mean (sd)	**Phrasal stress: mean (sd)**	**Compound stress: mean (sd)**	**Phrasal stress: mean (sd)**
Control	1508.2 (857.1)	1267.2 (678.9)	1291.2 (800.3)	1757.5 (928.9)
Dyslexic	1130.5 (693.0)	935.3 (593.5)	1145.6 (1056.5)	1322.2 (908.0)

The same 2x2x2 mixed ANOVA was run as before, but with RT as the dependent variable (Group as the between-subjects independent variable, and Item Type and Stress Pattern as within-subjects independent variables). The effect for Group was approaching significance, with the response times of the dyslexic group slightly faster than those of the control group ($F(1, 34) = 2.989$, $p = .093$). There was no effect for Item Type ($F(1, 34) = 2.001$, $p = .166$) or for Stress Pattern ($F(1, 34) = .186$, $p = .669$). There was, however, a significant interaction between Item Type and Stress Pattern ($F(1, 34) = 5.646$, $p = .023$) (see Figure 3.4). No other interaction was significant.

(Figure 3.4 is on the following page.)

Figure 3.4. Response times in the suprasegmental Recognition task (item type and stress pattern)



3.6 Discussion of Recognition results

3.6.1 Overall Recognition results: Beginning to address metalinguistic skills

As was outlined in Chapter 1, the rationale behind the Recognition task was that it would provide an analogy on both the segmental and suprasegmental level with the linguistic skills needed in order to learn to read and write successfully – specifically, the ability to focus on the auditory form of words in a kind of self-reflection or self-monitoring. Participants did not have to assign a meaning to the input they heard but were obliged instead to listen to the auditory form of the words and identify which one contained particular (specified) phonological units.

It may be recalled that the Recognition task is not being regarded here as a representational task, as participants were not required to access the meaning of what they heard – the focus was on the form of the words, and they were required only to identify either a segment or a stress pattern in the auditory material they heard. Strictly speaking, this task should be considered as something of a half-way house between the representational task (the Interpretation task) and the manipulation tasks which will be reported in the next two chapters. This is because, on the one hand, rather than drawing on mental representations alone as the Interpretation task does, the Recognition task has a clear metalinguistic aspect to it, in that it requires an analytical focus on the form of the auditory words, and on the other hand, its metalinguistic aspect is minimal (or, *merely* metalinguistic) in comparison with the manipulation tasks in Chapters 4 and 5 – it required nothing *more* than this analytical focus on the form of the auditory words.

Note that of course using the term *recognition* to characterise this task implies that the elements to be identified in the task are already known to the participant, and simply need to be noticed when they are presented. This is a valid characterisation of the task, since it can be assumed that both the segmental and the suprasegmental elements invoked by this task are indeed already known to the participants in both groups. From the results of the Interpretation task it is known that both groups of participants do already have securely in place at least the implicit knowledge of the elements which it targets. In this way, while administering the Interpretation task prior to the Recognition task ensured that metalinguistic demands were kept to a minimum in the Interpretation task, it also provided a basis for establishing that participants had the requisite knowledge in an implicit form before they undertook the Recognition task. Even if prior to coming to the experimental session as a whole they had never needed to bring this implicit knowledge to conscious awareness (especially in the case of the stress-based minimal pairs), in the task itself they were explicitly told which "sound" to listen for – so that even if it was *only* implicit prior to taking part in the task, they were now provided with a generalised auditory template ("hotdog" stress, the "DA-da" pattern, etc), to use as the basis for a genuine *recognising* of the target elements in the presented stimuli.

The results of this task, reported in §3.5 above, showed that overall, the group of participants with dyslexia and the group of control participants were equally proficient – counter to the predictions stated in Chapter 1, the group of participants with dyslexia did not find this task any harder than the group of control participants, either in its segmental or suprasegmental version, whether performance was measured in terms of the speed or the accuracy of their responses. The participants in both groups found the suprasegmental contrasts harder to identify than the segmental ones (and again, as in the Interpretation task, this outcome is expected pre-theoretically, in view of factors such as the reduced salience of stress-based contrasts relative to segmental contrasts), but the overall picture of the results suggests that dyslexics are not impaired in the ability to reflect on ('think about') the form of language, whether the elements to be focussed on are segmental and hence potentially permeated with orthographic information, or strictly a property of spoken rather than written language, as was the case with the stress patterns in the task.

A final general comment may be made here about the results of Recognition task in relation to the results of the Interpretation task (presented in Chapter 2): the response times in both versions of the Recognition task are noticeably shorter than they were in the Interpretation task, for both groups. This is partly due to the fact that the Interpretation task involved pictures, which the participants needed to process. Especially in the case of the suprasegmental version, these images were presented in colour, and were quite complex and detailed, but response times are also long for the segmental Interpretation pictures, a task which was very successfully performed by both groups (similarly, the filler items in the suprasegmental Interpretation task, which were fully semantically transparent, elicited response times which were only slightly shorter than those for the experimental items). The long response times are also partly due to the fact that the Interpretation task required meanings to be accessed, whereas in the Recognition task it was not required that the meanings of the words and phrases should be accessed.

3.6.2 The segmental version of the Recognition task

No difference was found between the groups in the segmental version of the Recognition task considered as a whole, nor when it was broken down according to whether the target item was a singleton consonant or part of a consonant cluster. It was also found that the items were easier when the analysis focused on singleton target consonants (as in *fussy*, *fuzzy*) compared to consonants which were part of a cluster (as in *slipper*, *flipper*). This was true of both groups, and the difference between the types of item was reflected both accuracy and response times. This finding fits well with the results of other studies, in that singleton consonants are generally recognised as being easier to process than consonants in clusters (from a developmental point of view, for example, see Vihman 1996). However, the finding that the groups did not differ in the task as a whole was not predicted by either the Phonological Deficit Hypothesis or the claims outlined in Chapter 1. It is also unexpected given findings reported elsewhere in the literature that even adult dyslexics are said to have persisting phonological awareness deficits (e.g. Bruck 1992, Fawcett & Nicolson 1995).

However, consideration of the task itself suggests that if it had been designed slightly differently, in a way which would have made it more challenging for the participants, it might have been more likely to be sensitive enough to uncover any basic metalinguistic analysis deficits which may nevertheless persist in adults with dyslexia. For example, the number of items where the target was part of a cluster could be increased, and the perceptual demands imposed by the choice of target segment could be varied, as could the orthographic consistency of the words selected. In addition, the location of the contrast could also be modified to make the task more likely to discriminate between the groups. Although all the contrasts were located either word-medially or word-finally or in clusters, most of them were located in the stressed syllable of the bisyllabic word (e.g. /Ůkãst□nd, Ůkãsp□nd/), rather than its unstressed syllable (/ãs□.nŮt, ãs□.nŮk/).[3] Since segments in stressed syllables are easier to identify than those in unstressed syllables, this feature of the stimuli may have masked any differences which might have existed between the groups. Similarly, the fact that only two segments were specified for the participants to recognise in the items, i.e. /t/ and /s/, may have made the task too predictable, and although the number of segments was limited to two, so as to correspond with the suprasegmental version and also avoid possible extraneous short-term memory demands, it might have been better to have used a larger number. A larger number of target segments would also increase the number of minimal pairs which are available with non-initial contrasts located in unstressed syllables.

The task paradigm could also have been made different, by making the presence of the target phoneme more unpredictable. As it was, participants always knew that the target phonemes /s/ or /t/ would certainly occur in one or the other of the presented items. An alternative method would have been to present participants with only one word, for them to state whether the target phoneme occurred in it or not (that is, for target /s/ they would respond 'yes' if the item was *fussy*, but 'no' if the item was *fuzzy*). The decision to present the two items together was motivated by the wish to keep the segmental and suprasegmental versions of the task as

[3] Three items in the /t/-list and two items in the /s/-list had their contrasts located in the unstressed syllable; these are marked in the list in Appendix C.

similar as possible. Although it would have been possible to give participants only one item at a time in the suprasegmental task, for them to judge whether it was end-stressed or not, it was thought at the time that this would make the suprasegmental version too easy, and the segmental version of the task was developed in accordance with the decision taken for the suprasegmental version.

3.6.3 The suprasegmental version of the Recognition task

When the suprasegmental Recognition task was analysed in detail, the findings overall combine to present a picture which does not support the view that basic metalinguistic skills in dyslexia are impaired in suprasegmental areas of phonology. Rather, there was a nearly significant group effect in the response time data, with the response times of the dyslexic group being slightly faster than those of the control group, although there was no difference between the groups in accuracy.

One way of accounting for why the dyslexic group showed no deficit in this task relative to the control group may be found by recalling that the prediction for the Recognition task which was based on the Metalinguistic Hypothesis presented in Chapter 1 was drawn from a conceptualisation of this task as one in which participants would be required to make the same metalinguistic judgments on suprasegmental minimal pairs which theoretically they had had to make earlier in development with segmental minimal pairs, in order to acquire what is called the alphabetic principle. The suprasegmental version escaped the orthography confound to the extent that the participants were unable to draw on any orthographic knowledge in order to make this judgment – the suprasegmental contrast is one which, due to the fact that it is not represented in writing in English, they had never been required to think about before. However, this task did not take into account the fact that the participants, being literate, were already used to thinking about the form of words – they had already, arguably, made this cognitive leap for literacy acquisition. In other words, although the task could be undertaken without input from orthographic representations of the contrast in question, it could *not* be undertaken without at least the possibility of having input from the previous experience of having to make these judgments for segments. This could be at least part of the explanation for why the results here turned out not to support my prediction – perhaps, when this cognitive step of reflecting on spoken words has been taken once, it is not so difficult to apply subsequently in different circumstances to different aspects of spoken language: once a person has become able (with whatever degree of facility) to think reflexively about the sounds of language from one perspective, such as in construing speech sounds as vertically segmentable in order to correspond with alphabetic symbols, it may not be too much of a stretch to think reflexively about the sounds of language from a different perspective, such as segmenting speech sounds horizontally in terms of their stress patterns, as required.

This does not, however, fully account for why the dyslexic group were performing with slightly faster response times than the control group, with equivalent accuracy. Since there was no interaction of group with either of the other factors, it does not seem that an explanation can be found in terms of the lexical status of the items, for example. Although there were effects and interactions involving the items, these were common to both groups. It is possible, however, that the dyslexic group might have found an advantage over the control group in the fact that this task required primarily the ability to focus on the form of the words. As was already noted, in this task it was not necessary to access or make use of lexical or semantic information relating to the auditory material which was being presented, and it is conceivable that individuals with dyslexia benefited more than the control group from the absence of this additional processing requirement. It is already known that children with dyslexia are less accurate than controls when required to provide names for pictures or definitions (Snowling et al 1988, Swan & Goswami 1997b), and that this deficit can also be seen in adults when there is an additional requirement for speed (Wolf et al 2000). This may suggest that accessing lexical information is less automatic for individuals with dyslexia than for non-dyslexic individuals. If in unimpaired processing of spoken words lexical information is accessed in an automatic way irrespective of whether it is strictly necessary in the context, then it is possible that for the control group the lexical or semantic aspects of the auditory material may have interfered with the requirement to focus on the form of the material, whereas if lexical information is accessed late or effortfully in impairments such as are hypothesised for dyslexia, no such interference would be seen. This, however, is a post hoc suggestion which goes beyond what the current experiments were designed to test (and it should also be noted that existing studies which cite word-finding difficulties in dyslexia typically refer to deficits in rapid automatised naming tasks and production tasks, which involve speed requirements and speech motor demands, rather than simply the question of whether the semantic aspects of lexical entries are activated on hearing spoken words in contexts where it is not necessary for the word meanings to be available).

In addition to the difference which was found between the groups, the properties of the items in the task were also found to have an effect on performance. Again bearing in mind that the idiomatic items with compound stress are real lexical items, the performance of the groups was compared according to what type of item was involved (whether genuinely ambiguous, like *steel warehouse*, or idiomatic, like *black+bird*) and in terms of the stress pattern which the participant was responding to (whether compound stress or phrasal stress). This analysis of the data also showed that there was an interaction between item type and stress pattern: phrasal stress made response times shorter in the ambiguous items and longer in the idiomatic items, while compound stress made response times longer in the ambiguous items and shorter in the idiomatic items. This pattern of results was not reflected in the accuracy data, however, where there was a main effect for item type (with higher accuracy in the ambiguous items than in the idiomatic items), and the interaction between item type and stress pattern did not quite reach significance (in the ambiguous items, accuracy was nearly significantly higher in items with compound stress than with phrasal stress, which would have indicated that, for both groups, the greater accuracy would have been achieved with longer response latencies).

It can also briefly be noted that these results for the interaction of item type and stress pattern in the Recognition task were not identical to what was found in the Interpretation task. Specifically, whereas in the Recognition task, accuracy was higher in the ambiguous items, in the Interpretation task, accuracy was higher in the idiomatic items. In other words, when the task was to find the meanings of the auditory stimuli, idiomatic (*hot+dog*-type) items were easier than ambiguous (*toy+factory*-type) items, but when the task was to identify the stress pattern of the auditory stimulus, it was easier in the ambiguous items than the idiomatic items. Additionally, although an interaction between item type and stress pattern was found in both tasks, in the Interpretation task this interaction was seen in the accuracy data, not in the response time data as in the Recognition task, and it was virtually the reverse of what was found in the Recognition task (although the interaction in the Recognition task was not quite statistically significant). Whereas in the Recognition task, the stress pattern affected accuracy in the ambiguous items (compound-stressed ambiguous items had slightly higher accuracy than phrasally stressed ambiguous items), in the Interpretation task, the stress pattern had a significant affect on accuracy in the idiomatic items instead (phrasally stressed idiomatic items had significantly higher accuracy than compound-stressed idiomatic items). It is possible that this is due to differences in the acoustic realisation of the items in these two tasks. The materials for the suprasegmental Interpretation and the suprasegmental Recognition task were produced by different speakers, and it may also be recalled that the syntactic and prosodic contexts differed in the two tasks (target items for the Interpretation task were read in a carrier sentence and were located sentence-medially, whereas for the Recognition task, the items were read as isolated citation forms). Notwithstanding these differences, it seems that duration cues may have been slightly less congruent with the syntactic structures in the Recognition materials relative to the Interpretation materials: as reported in Table 3.2 above, in compounds, duration was longer for the second element than the first element of both ambiguous and idiomatic types (whereas in principle it should have been shorter). No consistent relationship appears to hold between the participants' accuracy in the suprasegmental Recognition task and the durational cues, however, inasmuch as there is no effect of stress pattern and although the interaction between stress pattern and item type shows lower accuracy in the idiomatic compounds (where the lexically stressed syllable of the second element (e.g. *dog*) is longer than the lexically stressed syllable of the first element, e.g. *hot*), accuracy in the idiomatic phrases is just as low, in spite of these items having the expected duration pattern. Participants may have therefore used other cues (such as intensity) in addition to pitch and duration, to compensate for the inadequacy of the duration cues in the Recognition task.

A further comment on the suprasegmental version of this task is that, although it has been discussed here as a task in which participants must reflect metalinguistically on the auditory material, it could nevertheless be undertaken as a task of perceiving either an initial-stressed or a final-stressed syllable in the material they are presented with – that is, in terms of the acoustics, rather than as arbitrary and conventional units, or in other words, as a sound pattern-matching task rather than invoking any linguistic structural units. Although the segmental and suprasegmental versions of the task were designed to be as closely analogous as possible, the requirement to consider the stimuli as consisting of arbitrary and conventional components was perhaps lessened in the suprasegmental version since, even though the difference between compound and phrasal stress plays the same pivotal role in distinguishing word meaning as does the contrast in any segmental minimal pair, the stress distinction in the task itself could well have been identified on more of a perceptual pattern matching basis than on the grounds of its meaning-related function. Up to a point, this does constitute a problem for this task, since 'metalinguistic analysis' should ideally involve the participant dealing with units in his or her linguistic system. However, two considerations tend to minimise this potential problem. As was mentioned in §3.4 above , participants always took part in the Recognition task after the Interpretation task, where they not only had to draw on their existing implicit knowledge of the *ˈtoy factory*, *toy ˈfactory* contrast, but showed that whether they did or did not have dyslexia their knowledge of this contrast was intact. Additionally, as mentioned in §3.6.1, the instructions for this version of the task were framed so as to encourage participants to think in terms of the "hotdog" or "hot dog" pattern, and the task itself required not simply the perception of stress in a particular location but the correct identification of the pattern in one item rather than its minimally different counterpart. Even if this task is construed entirely as a perception task, then, this would not detract from the fact that it requires metalinguistic analysis in terms of implicit categories.

Finally, it is worth noting that the conceptual framework which originally motivated the experiment (the Metalinguistic Hypothesis of Chapter 1) may not itself have been sufficiently sensitive to the recurring factor of literacy experience. The emphasis in this hypothesis may therefore need to be shifted slightly in order to refine it, by considering that performance in the segmental version of the task is mediated through orthography in a way that is not possible in the suprasegmental version of the task. While we know that individuals with dyslexia have difficulty converging on the segmentation expected by English orthography, it may be the case that a different kind of segmentation, one which is not required by English orthography, does not pose a difficulty for individuals with dyslexia. Whereas for segments there is a need to build up what Ehri (1992) conceptualises as mental amalgams of both sound and orthographic information, no such mental amalgams are required or available for suprasegmental information in English, such that individuals with dyslexia, who are known to have difficulties organising their implicit knowledge along the lines of conventional orthography in order to call on it in situations where the conventional orthographic format of this knowledge is available, may not experience difficulty calling on their implicit knowledge in the absence of an orthographic counterpart. As Miles and Miles (1999) comment in a discussion of music and mathematics skills in dyslexia,

> "there is every reason for supposing that a suitably talented dyslexic can succeed at either; in both cases, however, there are basic problems that need to be overcome – not problems of mathematics or music as such but problems of mastering the notation in which mathematical or musical ideas are expressed" (1999: 152).

This is similar to what has been argued by, for instance, Castles et al (2003: 456), from the perspective of unimpaired adult readers: in phoneme deletion tasks they found that,

> "those with stronger orthographic skills were doing the task orthographically when they could, but that, when this strategy was of limited assistance (…), they were not much better at performing phoneme deletions than those with weaker orthographic skills."

3.7 Relation of performance to literacy measures

In this section, we examine the relationships which hold between the literacy skills of the two groups of participants and their performance in the Recognition task in the present chapter. Results for the control group are presented first, followed by results for the dyslexic group, and the results are discussed in §3.7.2.

3.7.1 Correlations of Recognition performance and WRAT scores

3.7.1.1 Results for the control group

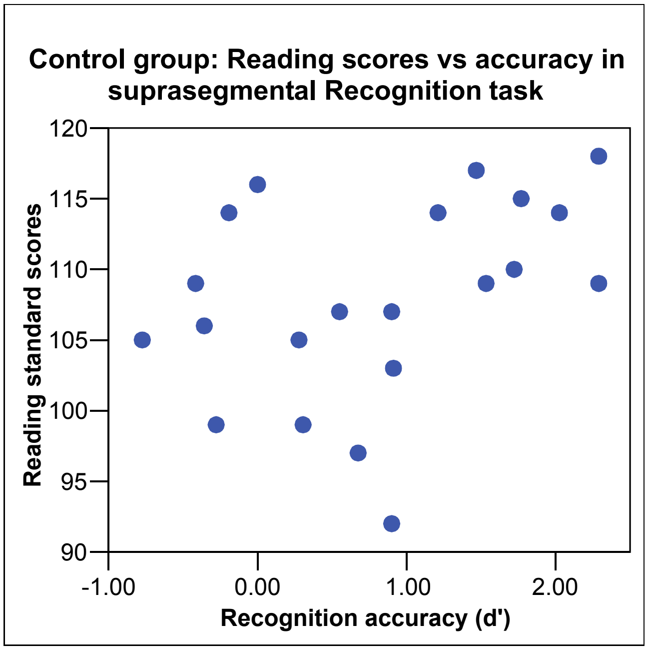
For the control group, there were no statistically significant correlations between either of the WRAT subtasks or the measures of performance in the Recognition task, although the correlation between suprasegmental Recognition accuracy and Reading scores approached significance (r = .379, p = .091). The full results (for both accuracy and response times, for both the segmental and suprasegmental versions of the task) are shown in Table 3.9. Note that the results of the correlation between suprasegmental Recognition response time and Spelling scores also appears to approach significance, but these values should be read in conjunction with Figure 3.6 below.

Table 3.9. Correlations of the control group's WRAT Reading and Spelling standard scores with performance (accuracy and response times) in the suprasegmental Recognition task

	WRAT Reading	WRAT Spelling
Segmental Recognition (*d'*)	r = .161 p = .486 n = 21	r = .010 p = .965 n = 21
Suprasegmental Recognition (*d'*)	r = .379 p = .091 n = 21	r = .190 p = .409 n = 21
Segmental Recognition (msec)	r = -.276 p = .226 n = 21	r = -.004 p = .986 n = 21
Suprasegmental Recognition (msec)	r = .231 p = .313 n = 21	r = .394 p = .077 n = 21

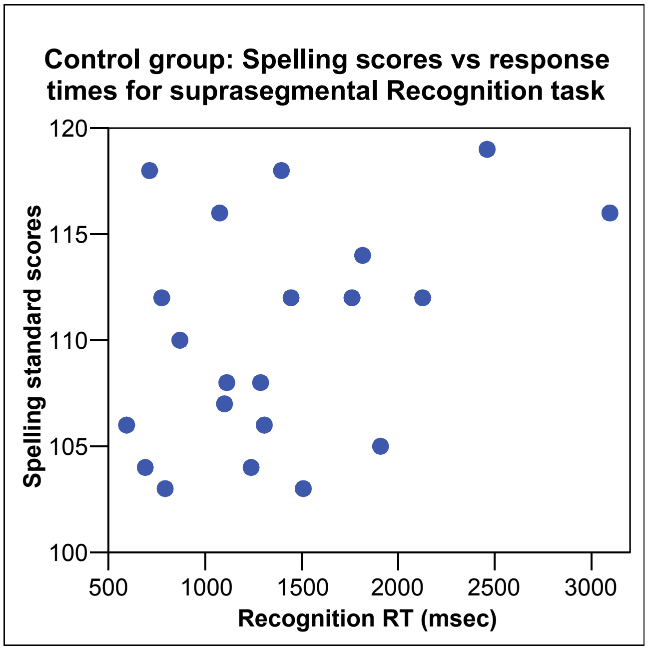
The relationship between the control group's Recognition accuracy scores and Reading performance is shown in Figure 3.5, where it can be seen that although the correlation was not statistically significant, the trend was for higher accuracy scores to be associated with higher Reading scores.

Figure 3.5. Control group's WRAT Reading scores against suprasegmental Recognition accuracy



The relationship between the control group's response times and Spelling scores is shown in Figure 3.6 (on the following page). However, it can be seen that the response times of one individual are longer than the rest, and when this individual's data is removed from the analysis, the correlation is no longer significant (r = .311, p = .182).

Figure 3.6. Control group's WRAT Spelling scores against suprasegmental Recognition response times



3.7.1.2 Results for the dyslexic group

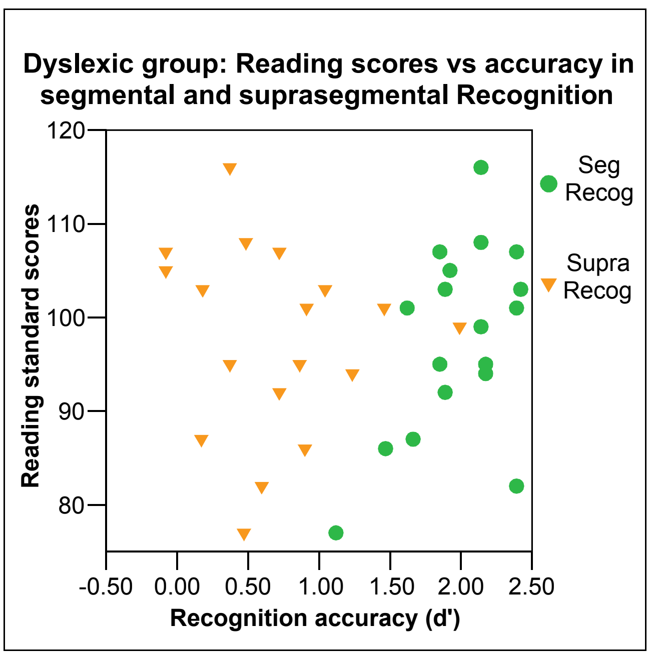
For the dyslexic group, accuracy in the segmental version was nearly significantly correlated with both Reading and Spelling performance. Response times in the Recognition task were correlated with WRAT Reading performance, although only for the suprasegmental version, where the correlation was positive and moderately strong (r = .555, p = .017); see Table 3.10. Note that the seemingly significant correlation between Reading and response times in the segmental version should be treated with caution, as will be shown below in relation to Figure 3.8.

Table 3.10. Correlations of dyslexic group's WRAT Reading and Spelling standard scores with accuracy in the suprasegmental Interpretation and Recognition tasks

	WRAT Reading	WRAT Spelling
Segmental Recognition (*d′*)	r = .433 p = .064 n = 19	r = .397 p = .093 n = 19
Suprasegmental Recognition (*d′*)	r = -.098 p = .698 n = 18	r = .311 p = .210 n = 18
Segmental Recognition (msec)	r = -.515 * p = .024 n = 19	r = -.379 p = .110 n = 19
Suprasegmental Recognition (msec)	r = .555 * p = .017 n = 20	r = -.041 p = .873 n = 20

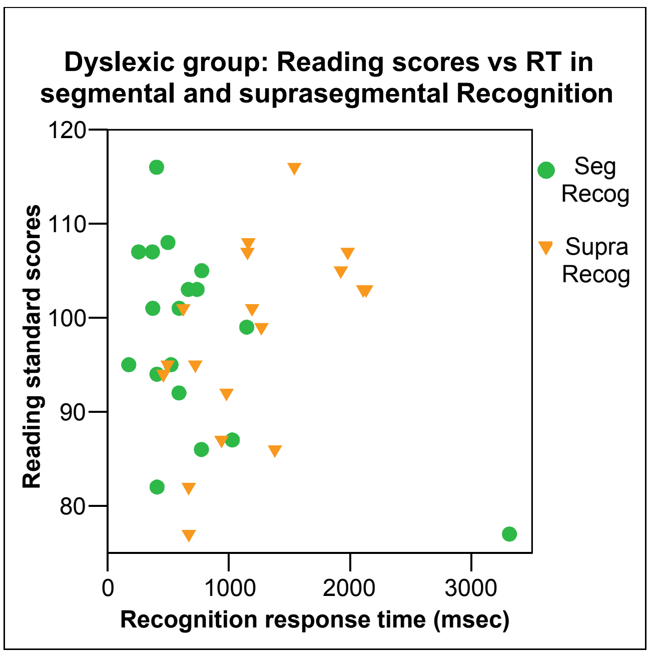
The nearly significant relationship between the dyslexic group's segmental Recognition accuracy and Reading performance is shown in Figure 3.7 below.

Figure 3.7. Dyslexic group's WRAT Reading scores against segmental and suprasegmental accuracy



The relation which appeared between Reading performance and suprasegmental Recognition response times was seen only in the dyslexic group, not the control group. Figure 3.8 shows response times for both the segmental and the suprasegmental versions of the task. It can be that the result for the segmental version has been skewed by one individual with particularly long response times. When this individual is excluded from the analysis, the correlation is no longer significant (r = -.138, p = .584). It should also be noted that in the significant correlation of Reading with suprasegmental response times, higher Reading scores are associated with longer response times.

Figure 3.8. Dyslexic group's WRAT Reading scores against segmental and suprasegmental Recognition response times



3.7.2 Discussion of the relationship between the Recognition task and literacy measures

Examining the relationship between performance on the suprasegmental Recognition task and scores in the WRAT Reading and Spelling subtasks was done with a view to establishing whether or not this task has a relationship with literacy measures which is comparable to the relation between literacy measures and the conventional 'phonological awareness' measures reported in the literature. For the control group, there was no statistically significant relationship between Recognition performance and WRAT measures, although the correlation between suprasegmental Recognition accuracy and WRAT Reading could be regarded as approaching significance. On the other hand, for the dyslexic group, Reading was found to be significantly correlated with suprasegmental Recognition response times (longer response times were associated with higher Reading scores) and Reading was also nearly significantly correlated with segmental Recognition accuracy.

If the results for the Reading performance of both groups are taken to suggest that there is some relationship between Reading and performance in either version of the Recognition task, this is consistent with the view that metalinguistic skills are important for reading development. The lack of a clear relationship between Reading and the segmental version of the task in the case of the control group is unexpected from the point of view that it is so widely accepted that some metalinguistic analysis is required in the process of learning to read. It may therefore be necessary to revise the Metalinguistic Hypothesis of Chapter 1, either by shifting attention away to something other than a 'merely' metalinguistic deficit, or perhaps by incorporating a developmental aspect into the hypothesis (such that, for example, while a 'merely' metalinguistic deficit may predominate in younger individuals with dyslexia, more 'challenging' means of testing metalinguistic analysis may be more appropriate in older individuals or adults with dyslexia. The nearly significant correlation between segmental Recognition and Reading (and also with Spelling) is consistent with all the available alternative predictions. In regard to the suprasegmental version, on the other hand, it may be recalled that in Whalley and Hansen's (2006) study of prosody in relation to the literacy performance of 9 year old typically developing children, one of the tasks was closely analogous to the present Recognition task, namely the 'DEE-dee' task, where participants had to state whether a phrase such as *Snow White* should be matched with 'DEE-dee' or 'dee-DEE'. It may be recalled from Chapter 1 that in Whalley and Hansen's study the children's performance on the 'DEE-dee' task was most clearly related to a measure of reading comprehension, rather than word identification. Since there was no comprehension component in the literacy measures in the present study, it is possible that clearer relationships may exist between the suprasegmental version of the task and the comprehension aspect of literacy than the single word decoding measure can show.

3.8 Conclusions arising from the Recognition task

In this chapter, it was investigated whether or not a group of individuals with dyslexia differed from a group of comparable individuals with no history of dyslexia on a phonological task which required participants to analyse a minimal pair so as to state which member of the pair contained a particular specified contrastive unit (such as stating whether /s/ occurred in *fussy* or *fuzzy*, and whether end-stress occurred in ˈ*steel warehouse* or *steel ˈwarehouse*).

Both groups performed at very high accuracy levels for the segmental version of this task, and no statistically significant difference was found between the groups. Moreover, although both groups found the suprasegmental version of this task harder than the segmental version, there was no evidence of an impairment in the dyslexic group in the suprasegmental version, as the dyslexic group was performing at least as successfully as the control group. The results of correlating the groups' performance in the Recognition task with the WRAT literacy measures were in general indicative of the fact that the dyslexic group's proficiency in the metalinguistic analysis of phonological segments is related to their literacy skills, and that their proficiency in the metalinguistic analysis of suprasegmental information is not so closely related. The overall thrust of the results of this chapter is therefore that the dyslexic group shows no evidence of a deficit in the metalinguistic analysis of words in terms of segments (although this should be treated tentatively due to the limitations of the task), and no evidence of a deficit in the metalinguistic analysis of suprasegmentals, and that the two phonological domains are related in different ways with their literacy skills.

The results of the Recognition task do not therefore support the Metalinguistic Hypothesis put forward in Chapter 1, where it was predicted that a deficit in metalinguistic skills would be apparent in both the segmental version and the suprasegmental version of the task. So although the argument of Chapter 1 was partially supported by the results of the Interpretation task in Chapter 2, in that there is no evidence of impairment in the dyslexic group in areas of phonology which do not overlap with orthography, it has failed to find support in this chapter from the performance of the two groups in the Recognition task. The same questions also remain for the Phonological Deficit Hypothesis, at least in relation to the null results of the segmental version of the task, which equally fail to support the prediction that impaired segmental representations will evidence themselves in impaired segmental metalinguistic skills. The lack of evidence for a deficit in the suprasegmental version of the Recognition task can however be seen as inconsistent with the broad reading of the hypothesis and consistent with the narrow reading: if suprasegmental representations are not impaired, there is no reason to expect that the ability to undertake metalinguistic analysis of suprasegmental aspects of spoken language should be impaired.

The two tasks which have been reported so far were carefully designed to keep *representations* separate from *phonological awareness*, in the case of the Interpretation task, and then in the Recognition task, within the broader construct of phonological awareness itself, to keep *'merely' metaphonological* skills separate from the phonological *manipulation* skills which will be investigated in the following chapters. In Chapter 2, we saw the results of testing phonological representations (in the sense of implicit knowledge of sound patterns specific to spoken language), and in the present chapter, we have seen the results of testing phonological awareness in the sense of basic metalinguistic analysis that does not involve any extra cognitive processes in addition to the metalinguistic analysis itself. We are now in a position to examine how this group of dyslexics compares with the control group in traditional phonological awareness skills which involve not only basic metalinguistic analysis but also the ability to manipulate phonological units, whether segmental or suprasegmental. More particularly, now that Chapters 2 and 3 have established that neither the representation of suprasegmental information nor the ability to undertake a basic analysis of the suprasegmental form of spoken words is any weaker in the dyslexic group than in the control group, the question which will be addressed in the following two chapters is whether or not the suprasegmental side of phonology manipulation skills is also preserved in this group of participants.

Chapter 4

The Pig Latin task

4.1 Introduction

It was seen in Chapters 2 and 3 that there is no evidence that suprasegmental skills in this group of individuals with dyslexia are impaired, when they were tested in two different ways, namely in terms of representations of quasi-contrasts, and in terms of basic metalinguistic analysis skills. The implications which these particular findings have for the Phonological Deficit Hypothesis will be dealt with in the discussion in Chapter 6, but one question which arises immediately from these results is whether this group of individuals with dyslexia will be impaired in suprasegmental versions of conventional 'phonological awareness' tasks, when these tasks involve not only a basic level of metalinguistic analysis, but also the requirement to extract phonological units from their contexts in words and manipulate them. It has already been reported in the literature that adults with dyslexia show a deficit relative to controls in segmental manipulation tasks (Bruck 1992, Judge et al 2006, Pennington et al 1990, Snowling et al 1997, etc), but the tasks reported in this chapter and the next are designed to address the question, as yet unaddressed in the literature, of whether the same deficit will be seen in tasks where the elements to be manipulated are suprasegmental.

The task reported in this chapter is a Pig Latin task, with both a segmental and suprasegmental version. Participants were required to identify a phonological unit within a word, and then extract it from its original environment and move it to a different location in the word. This task in its segmental versions has been used in previous studies to demonstrate that phonological awareness deficits persist into adulthood in individuals with dyslexia (Pennington et al 1990, Gottardo et al 1997, Downey et al 2000). The main focus of interest in this chapter is in whether any differences occur between the two groups in the segmental and suprasegmental versions of this task, assuming that the versions are as comparable as possible.

Here again, given that the Phonological Deficit Hypothesis is open to two readings of its core claim, different predictions are made as to the outcomes of this task. Under the broader reading of the Phonological Deficit Hypothesis, where all kinds of phonological representations (both segmental and suprasegmental) are hypothesised to be impaired, it is predicted that a suprasegmental deficit will become apparent in these manipulation tasks. Under the narrower reading of the Phonological Deficit Hypothesis, where only segmental representations are said to be impaired, it is not predicted that any suprasegmental deficit will be found. On the other hand, if the argument presented in Chapter 1 is accepted, it can be built on so as to predict that a deficit will be found in suprasegmental as well as segmental manipulation tasks. Note that the position of Chapter 1 does not necessarily imply that a deficit should be seen only in segmental manipulation tasks (where there is an influence of orthography), since this argument in its essence makes more of a distinction between implicit representations and explicit analysis and manipulation than between segmental and suprasegmental areas of phonology. In other words, it is hypothesised on the basis of Chapter 1 that whatever phonology-related deficit exists in dyslexia, it is not in implicit phonological knowledge of either sort (whether segmental or suprasegmental), but in the application of phonological knowledge, or the bringing of implicit knowledge to explicit introspection and awareness. The trigger for this kind of meta-linguistic skill in the case of "segmental phonology" is the need to acquire alphabetic literacy, and although in English there is no particular trigger or pressure applied for bringing implicit knowledge of "suprasegmental phonology" to explicit awareness, the necessary trigger is here provided by the experimental context and the demands of the tasks presented. In this case, by analogy with the known deficits in the case of segmental phonology, it is predicted that the requirement imposed by these tasks will make a deficit apparent in suprasegmental areas of phonology.

The structure of this chapter is as follows. Details of the materials for the Pig Latin task in its segmental and suprasegmental versions are reported first of all, in §4.2. As this section will demonstrate, the key principle behind the design of the tasks was to maintain as close as possible a correspondence or analogy between conventionally used segmental Pig Latin tasks and the suprasegmental versions, developed specifically for this study. After a brief reminder of the characteristics of the two groups of participants (§4.3), a description of the experimental procedure is provided in §4.4.

The results of the Pig Latin task are presented in the subsequent section (§4.5). Following the format of the previous two chapters, the results of comparing performance in the segmental and suprasegmental domains will be presented first, followed by the results of the more detailed analysis of the two versions in turn.

As was done previously, §4.7 examines the relationship between the performance of the two groups in the Pig Latin task and their performance in the WRAT literacy tests. Again, the purpose of this analysis is to confirm that the skills being tapped by the tasks devised for this study bear the same relation to standard measures of literacy proficiency as tasks which are known from existing studies to be predictive of literacy ability. Although associations between phonological awareness and literacy have most frequently been experimentally demonstrated for children rather than adults, a few studies have shown these links for adults with dyslexia too.

Specifically for Pig Latin tasks, Gottardo et al's (1997) study of adults with dyslexia showed that WRAT Reading performance was significantly correlated not only with phoneme and syllable deletion performance, but also with a segmental pig Latin task such as Pennington et al (1990) used. Since there is precedent for expecting that performance in the segmental version of the Pig Latin task will be correlated with the WRAT measures, the main focus of interest in this section is whether any correlation will also be found with performance in the suprasegmental version.

Concluding remarks on the basis of the discussions in §4.6 and §4.7.2 will be made in §4.8.

4.2 Pig Latin materials

4.2.1 Materials for segmental Pig Latin task

The items for this task were a subset of the items used by Pennington et al (1990). All the monosyllabic items in Pennington et al's list were discarded, on the assumption that such short words might have been too easy for adult participants, and so as to keep the task roughly equivalent in length to the other tasks in the battery. In addition, all the items in the original list which had digraph onsets were discarded. By keeping the links between the orthographic form of the word and its segmental composition equally transparent throughout the task, it was intended that the amount of recourse which could be made to orthographic knowledge would be kept constant. This left 35 items remaining from Pennington et al's original list, all of which were used as stimuli in this task. All 35 items were bisyllabic. Twelve began with biconsonantal clusters (e.g. *blanket*), twelve began with triconsonantal clusters (e.g. *splatter*), and eleven began with a singleton consonant (e.g. *habit*). The complete stimulus list is provided in Appendix D.

The Pig Latin form of an item was created following the method used by Pennington et al (1990). In their Pig Latin task, the initial consonant is removed from the start of the word, moved to the end of the word, and made the onset of an extra syllable suffix whose nucleus was always /e/. If the original word was *blanket* /blaŋkət/, for example, it would become /laŋkət-be/. Note that unlike in some types of Pig Latin task, it is strictly only the first consonant of the word that is manipulated here, rather than, for example, the whole onset.

Half of the stimulus items (n = 18) were paired with the correct Pig Latin form, and half (n = 17) were paired with foils. Equal numbers of singleton, biconsonantal, and triconsonantal items were matched with the correct form and the foil. Foils came in four different types, again following the methods and terminology of Pennington et al (1990): ‘addition’ foils, where the first onset consonant was retained in its original location in addition to moving to the end (*blanket-bey*); ‘omission’ foils, where the consonant was produced neither in its original location nor at the end of the word (*lanket-ey*); ‘non-segmentation’ foils, where the onset cluster was not segmented and no consonants were moved to the end of the word (*blanket-ey*); and finally ‘cluster’ foils, where the whole consonant cluster was moved to the end of the word (*anket-bley*).

The auditory stimuli for this task were read out from lists by a number of different speakers and the recordings were examined to ensure that each word and its corresponding manipulated form was produced clearly and with a neutral citation form intonation. For all the tasks reported in this chapter, the speaker who was judged to produce the clearest forms was a phonetically trained male native speaker of Scottish English. The stimuli were presented for reading in several separate lists, corresponding to which type of manipulation they were to be produced with (i.e.

correct Pig Latin, addition foil, omission foil, etc). The order of presentation was randomised within each list for each speaker.

4.2.2 Materials for suprasegmental Pig Latin task

The items consisted of 34 tri-syllabic words, half exemplifying a SWW stress pattern (e.g. *'ca.len.dar*) and half with a WSW pattern (e.g. *dog'ma.tic*). The complete stimulus list is provided in Appendix D.

The suprasegmental Pig Latin form was designed to be as similar as possible to the segmental version, within the constraints imposed by moving from the segmental to the suprasegmental domain. The procedure which was developed was as follows. To create the Pig Latin form of an item, the main stress of the item should be moved one syllable towards the end of the word, and an extra syllable should be added at the end (arbitrarily specified as /ta/). For example, the original word *'ca.len.dar* would become *ca.'len.dar-ta*, and *dog.'ma.tic* would become *dog.ma.'tic-ta*. Note that it was only the location of the word's main stress which was affected, not the order of the syllables or segments. This procedure maintained all the key characteristics of the modifications involved in the segmental Pig Latin task: the identification of a particular phonological element (either the first segment in the word or the main stress in the word), changing the location of that element (either by moving it to the very end of the word or by moving it leftwards to the next place where it could be pronounced), and adding an extra unit at the end of the word (either a vowel or a CV syllable, both arbitrarily constituted). Note too (a) that the smallest word which would allow for this kind of manipulation is one with three syllables, as the WS (iambic) stress pattern in two-syllable items is much less frequent than the SW (trochaic) pattern and thus more marked, and (b) that only the SWW and WSW patterns allowed for stress to be moved rightwards within the original word, and as a result, words with the WWS pattern were not eligible to be used as stimuli in this task.

Half the items were paired with the correct Pig Latin form, and half were paired with foils (there were equal numbers of correct forms and foils with SWW and WSW patterns). Foils came in three different types, with equal numbers of items exemplifying each type: one type where the stress remained in the same place (*'ca.len.dar-ta*, *dog.'ma.tic-ta*), one for SWW items where stress moved two places towards the end rather than only one place (*ca.len.'dar-ta*), and one for WSW items where stress moved backwards rather than forwards in the word (*'dog.ma.tic-ta*).

4.3 Participants

The individuals who participated in the Pig Latin task were the same participants as those who took part in the previous two tasks (see §2.3 and the complete details in Appendix A).

4.4 Procedure for Pig Latin task

As before, participants were tested individually and the order of presentation of versions of the Pig Latin task was alternated between participants, in tandem with the order of presentation of the Spoonerism task (see §5). As before, the segmental versions of both these tasks were always administered prior to the suprasegmental versions, so that the format of the task would be familiar to the participants when they came to do the stress-based versions, although half the participants did both versions of one task followed by both versions of the other, and the other half did the segmental versions of the two tasks followed by the two suprasegmental versions. Equal numbers of participants did the tasks in the order 'Pig Latin before Spoonerisms' and the order 'Spoonerisms before Pig Latin'. These tasks were administered in the same session as the Interpretation and Recognition tasks, but always after these two tasks, in order to keep to a minimum the amount of metalinguistic analysis that would be brought to bear on the Interpretation and Recognition tasks. The Pig Latin and Spoonerism tasks together took approximately 25 minutes to complete.

As in the previous tasks, auditory stimuli were played through headphones to participants sitting in a sound-deadened booth facing a computer monitor with a keyboard. Participants made their response using specified keys on the keyboard. They were given as much time as they needed to make their response and there was a pause of one second after the participant's response before the start of the next trial.

For the Pig Latin task, careful instructions as to the nature of the manipulation were provided verbally to each participant, along with either one or two items for the participants to practice the manipulation out loud for themselves before doing the task, depending on how comfortable they felt with the particular manipulation procedure. It was ascertained that each participant understood the manipulation procedure before they began the task; as many practice items as necessary were provided until the participant signalled that he or she was ready to begin the task (usually no more than one extra practice item). With the aim of minimising any tendency for participants to rely on the spellings of words rather than their phonological form in performing the task, all the instructions and examples were always provided in terms of 'sounds' ('the very first sound in the word') – no written examples were provided in the on-screen instructions presented by E-Prime. Full instructions for both versions of the Pig Latin task are provided in Appendix D.

For the Pig Latin task, participants heard the original word followed by a manipulation of the word, with an interval of 500 msec between the word and its manipulation. Participants were instructed to state whether the manipulation they heard was correct or not, in terms of the manipulation procedure which they had practiced. After the stimulus item was played, participants were shown a screen containing the word "yes" presented on the left hand side of the screen and "no" on the right hand side. Note that the participants were not required to produce the manipulation; rather their task was to judge whether the manipulation was a correct Pig Latin form, responding 'yes' or 'no' accordingly. The decision was taken to ask the participants to judge the correctness of a manipulated form rather than producing the manipulation themselves in order that the format in which participants made their responses would remain consistent throughout the entire testing session, and also so that the scoring procedure would be simplified (by eliminating the need for transcription). This decision is discussed further in §4.6.2 below.

As before, the Pig Latin task was presented using E-Prime (Psychology Software Tools, Pittsburgh, PA).

4.5 Results of the Pig Latin task

Both accuracy and reaction time data were collected for each task.

Accuracy was again measured using d'. However, it should be noted that since this was a 'Yes-No' experiment, the formula used for calculating d' was the difference between the z-transformed 'hit' rate (H) and 'false alarm' (F) rate, i.e., without the correction which is used for the 2-Alternative Forced Choice tasks (the

Interpretation and Recognition tasks in the present study, as mentioned in §2.4) (Macmillan & Creelman 2005):

$$d' = z(H) - z(F)$$

where H refers to the 'hit' rate and F refers to the 'false alarm' rate. The same procedure was used as before for dealing with proportions of 0 and 1 in the calculation of d' (see §2.4).

Response time was measured in milliseconds (for correct responses only). For each participant, response times which were longer or shorter than 2 standard deviations from his or her mean response time were excluded from the analysis, along with the corresponding 'yes/no' decision.

4.5.1 Overall Pig Latin results

This task aimed to test how well participants could identify a phonological unit within a word, and then extract it from its natural environment and move it around in the word. The 'units' in question in this task were either the initial segment in a word (e.g. /b/ from *blanket*) or the main stress in a word (i.e. S from SWW, or in an alternative notation, ˈ from ˈ˘˘).

Accuracy results (d') for the segmental and suprasegmental versions of the Pig Latin task are shown in Table 4.1. For information, accuracy expressed as percentages was as follows: in the segmental version, 89.8% for the control group and 82.9% for the dyslexic group; in the suprasegmental version, 73.9% for the control group and 69.9% for the dyslexic group.[1]

[1] Although the accuracy of both groups is fairly high in the segmental version of the task, neither group reaches ceiling (as confirmed by Kolmogorov-Smirnov tests for both groups and both versions of the task).

Table 4.1. Accuracy (*d'*) for segmental and suprasegmental versions of the Pig Latin task

	Segmental version: mean (sd)	Suprasegmental version: mean (sd)
Control	3.18 (0.48)	1.80 (1.10)
Dyslexic	2.51 (0.70)	1.40 (0.90)

A 2x2 mixed ANOVA was run, with accuracy as the dependent variable, phonological Domain as the within-subjects factor, and Group as the between-subjects factor. There was a significant main effect of Group, with the control group showing higher accuracy than the dyslexic group ($F(1, 39) = 6.943$, $p = .012$). There was a significant main effect of Domain, with lower accuracy in the suprasegmental version than the segmental version ($F(1, 39) = 61.268$, $p < .001$). There was no interaction ($F(1, 39) = .815$, $p = .372$). This is shown in Figure 4.1 below.

Figure 4.1. Accuracy in segmental and suprasegmental versions of the Pig Latin task

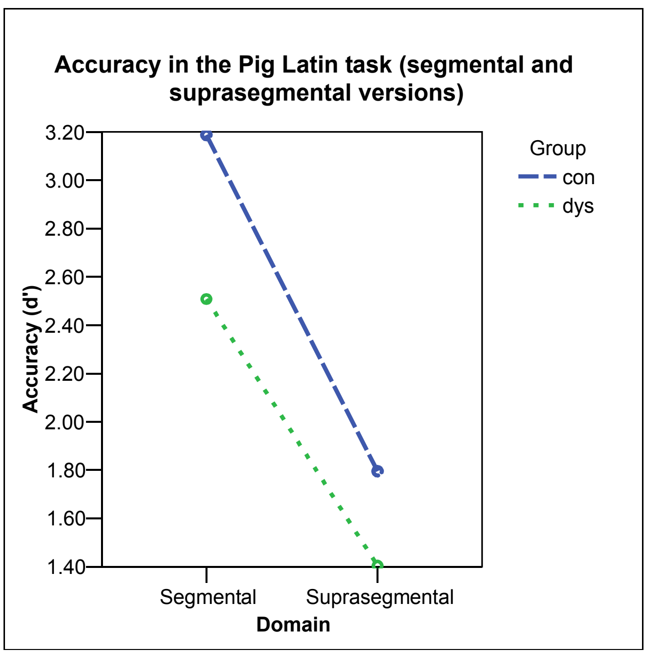


Table 4.2 shows the response times for the segmental and suprasegmental versions of the Pig Latin task.

Table 4.2. Response times (msec) for segmental and suprasegmental versions of the Pig Latin task

	Segmental version: mean (sd)	**Suprasegmental version: mean (sd)**
Control	1004.3 (639.8)	1865.2 (1177.9)
Dyslexic	1674.1 (1084.9)	2223.2 (1483.7)

A 2x2 mixed ANOVA was carried out, with RT as the dependent variable, Group as the between-subjects independent variable, and phonological Domain as the within-subjects independent variable. Although response times were shorter in the control group than the dyslexic group, there was no effect of Group ($F(1, 39) = 2.675$, $p = .110$). There was a significant main effect of Domain, with longer response times for the suprasegmental version ($F(1, 39) = 18.716$, $p < .001$). There was no interaction ($F(1, 39) = .915$, $p = .345$).

4.5.2 Results of the segmental Pig Latin task

In the segmental Pig Latin task, as described in §4.2.1 above, the consonant segment which was involved in the manipulation had to be extracted from one of three different kinds of environment, depending on what kind of onset it belonged to in the original word. The onsets in the original words consisted of either a singleton consonant (e.g. *habit*), a biconsonantal cluster (e.g. *blanket*), or a triconsonantal cluster (e.g. *splatter*). On the basis of existing findings and the predictions of the Phonological Deficit Hypothesis, it could be expected that the requirement to move singleton onset consonants would pose less of a difficulty for the dyslexic participants, compared to the requirement to extract the first consonant from a biconsonantal or triconsonantal cluster before being able to move it.

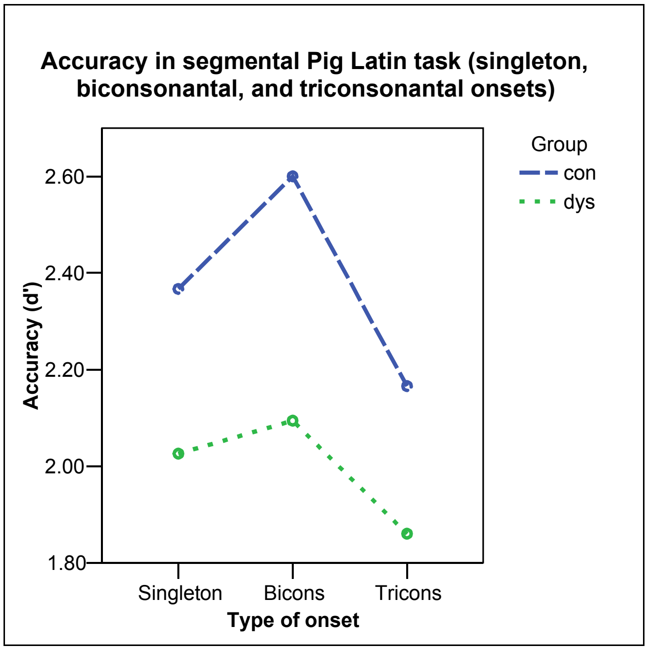
The accuracy of both groups in these three types of item is shown in Table 4.3.

Table 4.3. Accuracy (*d'*) for singleton, biconsonantal, and triconsonantal onsets in the segmental Pig Latin task

	Singleton onset: mean (sd)	Biconsonantal onset: mean (sd)	Triconsonantal onset: mean (sd)
Control	2.37 (0.37)	2.60 (0.22)	2.17 (0.53)
Dyslexic	2.03 (0.67)	2.09 (0.67)	1.86 (0.81)

A 3x2 mixed ANOVA was run, with accuracy as the dependent variable, Consonant Number (singleton, biconsonantal, triconsonantal) as the within-subjects factor, and Group as the between-subjects factor. There was a significant main effect of Group, with higher accuracy in the control group than in the dyslexic group ($F(1, 39) = 12.568$, $p = .001$), and also a significant main effect of Consonant Number ($F(2, 78) = 3.614$, $p = .032$). There was no interaction ($F(2, 78) = 0.117$, $p = .369$). The effect of consonant number, however, was not in the expected direction: accuracy was higher in the biconsonantal items than in either of the two other types of item. (See Figure 4.2 below.)

Figure 4.2. Accuracy in the segmental Pig Latin task (singleton, biconsonantal, and triconsonantal onsets)



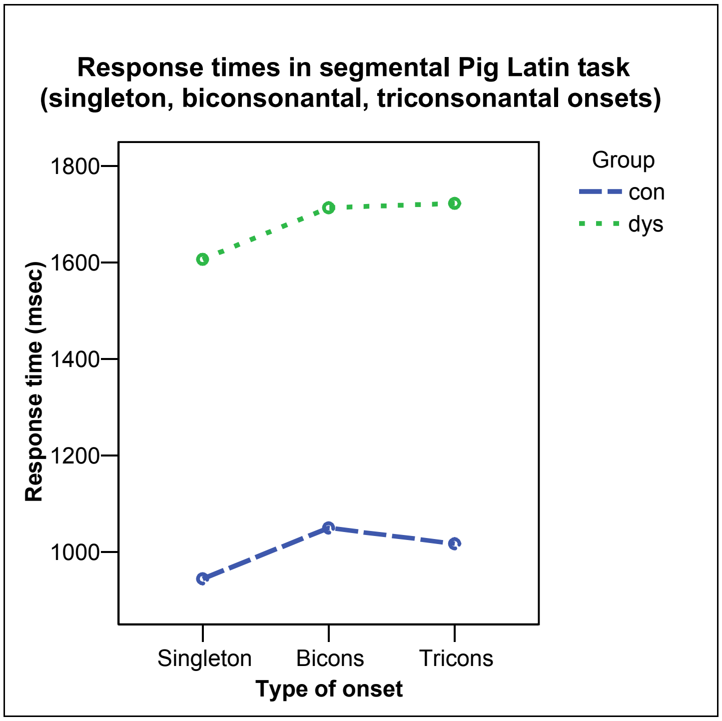
Response times for the three conditions are shown in Table 4.4 below.

Table 4.4. Response times (msec) for singleton, biconsonantal, and triconsonantal onsets in the segmental Pig Latin task

	Singleton onset: mean (sd)	**Biconsonantal onset: mean (sd)**	**Triconsonantal onset: mean (sd)**
Control	944.5 (537.9)	1049.9 (709.7)	1017.2 (767.2)
Dyslexic	1606.5 (1032.1)	1713.5 (1073.4)	1722.6 (1279.4)

A 3x2 mixed ANOVA was run, with RT as the dependent variable, Group as the between-subjects variable, and Consonant Number (singleton, biconsonantal, triconsonantal) as the within-subjects variable. A significant main effect was found for Group, with the control group taking less time to respond than the dyslexic group ($F(1, 39) = 5.935$, $p = .020$). It can be seen from Figure 4.3 below that the response times of the both groups were slightly lower for items with singleton onsets than the other kinds of item, which would have been the expected result, but the effect of Consonant Number was not significant ($F(2, 78) = 1.302$, $p = .278$). There was no interaction ($F(2, 78) = .058$, $p = .944$).

Figure 4.3. Response times of both groups in the segmental Pig Latin task



4.5.3 Results of the suprasegmental Pig Latin task

The only within-task variable in the suprasegmental Pig Latin task was the stress pattern of the original word form which was presented for manipulating, i.e. whether it had a SWW pattern (e.g. *'calendar*) or a WSW pattern (e.g. *dog'matic*).

Although there was no immediate *a priori* or theoretically motivated expectation that either of these patterns would be more difficult than the other for either group, it turned out that both groups turned out to respond with greater accuracy to items which had a SWW stress pattern compared to items with the WSW pattern (although the stress patterns did not elicit differences in the time taken to respond).

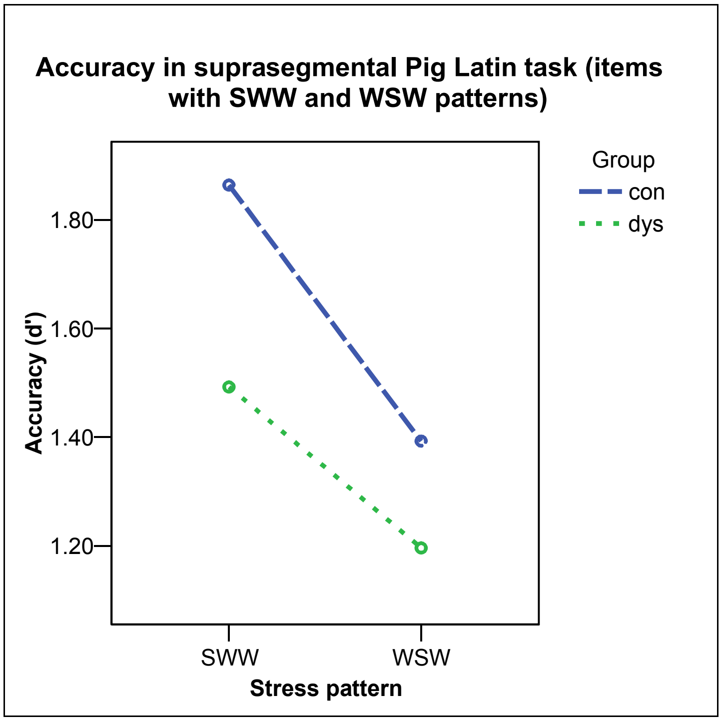
The accuracy data is shown in Table 4.5.

Table 4.5. Accuracy (*d'*) for items with SWW and WSW stress patterns in the suprasegmental Pig Latin task

	SWW pattern: mean (sd)	WSW pattern: mean (sd)
Control	1.86 (0.87)	1.39 (1.25)
Dyslexic	1.49 (0.88)	1.20 (1.02)

A 2x2 mixed ANOVA was run with accuracy as the dependent variable, Stress Pattern as the within-subjects factor, and Group as the between-subjects factor. This analysis showed no effect for Group ($F(1, 39) = 1.070$, p = .307). There was a significant main effect for Stress Pattern; both groups were significantly more accurate in the items with SWW patterns ($F(1, 39) = 5.785$, p = .021). There was no interaction ($F(1, 39) = .301$, p = .586). See Figure 4.4.

Figure 4.4. Accuracy in the suprasegmental Pig Latin task (items with SWW and WSW stress patterns)



Response time data is shown in Table 4.6.

Table 4.6. Response times (msec) for items with SWW and WSW stress patterns in the suprasegmental Pig Latin task

	SWW pattern: mean (sd)	WSW pattern: mean (sd)
Control	1789.8 (1173.7)	2056.7 (1329.5)
Dyslexic	2145.1 (1718.4)	2225.7 (1291.9)

A 2x2 mixed ANOVA was run with RT as the dependent variable, Stress Pattern as the within-subjects variable, and Group as the between-subjects variable. There were no effects or interactions in the response time data: there was no effect for Group ($F(1, 39) = .400$, $p = .531$), or for Stress Pattern ($F(1, 39) = 1.637$, $p = .208$), and no interaction of Group and Stress Pattern ($F(1, 39) = .471$, $p = .497$).

4.6 Discussion of Pig Latin results

4.6.1 Overall Pig Latin results: manipulations involving one phonological unit

The general purpose of the Pig Latin task was to establish whether the deficits which individuals with dyslexia are known to have in segmental manipulation tasks would also be apparent in suprasegmental manipulation tasks. Although this question will also be addressed from the perspective of the Spoonerism task which will be presented in the next chapter, what is specific to the Pig Latin task itself is that it requires the manipulation of only one phonological unit at a time – either the word's initial consonant (e.g. /b/ from *blanket*) or the word's main stress (e.g. S from a WSW pattern, as in *dog'ma.tic*). The unit is required to be extracted from its original environment in the word and moved away, either to the end of the word to form part of an additional syllable in the case of the segmental version (*blanket* → *lanket-bey*), or else to the next available position in the word in the case of the suprasegmental version (*dog'ma.tic* → *dog.ma.'tic-ta*). In both versions the original word is also supplemented by the addition of the extra syllable on the end, but the key point of the manipulation itself is to identify the unit in question and move it to a new position in the word.

When the performance of the two groups of participants was compared on the two versions of the Pig Latin task, the control group was shown to have higher accuracy than the dyslexic group. Both groups also found the suprasegmental version harder than the segmental version (whether performance was measured in terms of accuracy or time taken to respond).

4.6.2 The segmental version of the Pig Latin task

In the segmental version of this task, a difference was found between the performance of the two groups. Specifically, the dyslexic group were less accurate than the control group and took longer to respond. This finding corroborates what has already been reported in the literature (e.g. Pennington et al 1990, Downey et al 2000), that individuals with dyslexia have difficulty performing such segmental manipulation tasks even in adulthood. Additionally, whereas Birch and Chase (2004) found that a deficit in pig Latin performance was seen in only those students with dyslexia whose reading and spelling performance was not 'compensated' to within the normal range (not in dyslexic students with compensated reading and spelling), the group of individuals with dyslexia in the present study showed the deficit even though their reading and spelling scores are within the normal range, or 'compensated' according to the definition used by Birch and Chase (2004).

When performance on the segmental task was examined in greater detail, an unexpected finding was made: the accuracy of both groups was higher in the items with biconsonantal onsets (e.g. *blanket*) than those with singleton onsets (e.g. *habit*). This finding is contrary to what would be expected on the basis of the existing literature. The segmentation of clusters is something that young children are known to have difficulty with (Bruck & Treiman 1990), and in dyslexia, cluster segmentation difficulties have been found both in younger children and also persisting into adolescence (Fawcett & Nicolson 1995). As Pennington et al (1990) also found in the study which the present segmental Pig Latin task was based on, in adults with dyslexia, accuracy was lower in the items with biconsonantal cluster onsets (and response times were also by and large longer). It may be noted, however, that Pennington et al's study included both a 'production' and a 'recognition' version of the Pig Latin task, and the effect of cluster onsets was more clear in the 'production' task, where participants had to produce the Pig Latinised forms themselves, compared with the 'recognition' task, where participants were required to judge whether the presented form was correctly Pig Latinised or not. It was the 'recognition' paradigm which was used in the present study (with a subset of the materials used in Pennington et al's study), and it seems that Pennington et al's less clear-cut results in their 'recognition' Pig Latin are echoed in the present study, rather than their unequivocal results for the 'production' Pig Latin task.

Nevertheless, no clear reason seems to be available for why the performance of the two groups of participants in this study was better in the items with cluster onsets compared to the items with singleton onsets. A finding that there was no difference between these two types of onset would fit better with the results of Pennington et al's study, rather than the finding that the biconsonantal cluster items are easier than the singleton onsets. Examination of the participants' performance shows that the accuracy of one participant in each of the groups was > 2 sd below the group mean specifically in the singleton condition of this task, but excluding these participants does not change the overall pattern of the results (the mean accuracy in the biconsonantal items is still higher than in the singleton items). Additionally, examination of the materials does not provide evidence of a source for this unexpected performance. For instance, there is no evidence that any one particular biconsonantal item was especially easy and skewing the responses. Although one item among the singletons is given a correct response by only 15 of the control participants (all the other items in both the singleton and biconsonantal conditions are given a correct response by 19-21 of the control participants), excluding this item from the calculation of *d*′ values for the control group does not result in an increase in the group's accuracy. The item in question is *happen*, which is paired with the 'addition' foil *happen-hey*, and it does not seem to be treated any differently from the rest of the items by the dyslexic group. It can also be confirmed that the ratio of correctly pig latinised forms to foil forms is the same within the three types of item. Additionally, both the singleton and the biconsonantal items include the same kinds of foil ('addition' foils, such as *habit-hey* or *blanket-bey*, and 'omission' foils such as *abit-ey* or *lanket-ey*, for the words *habit* and *blanket* respectively), so there is no reason to think that these foil types could have advantaged the participants in the biconsonantal items relative to the singleton items. At the same time, though, the singleton items by definition did not have 'cluster' foils, and it is possible that these may have been easier to identify than foils involving a single consonant, even if there was an underlying weakness in the ability of the dyslexic group to segment clusters into their constituent consonants. It would appear therefore that the better performance on the biconsonantal items is not simply an artefact of the materials, even though it is unexpected, and indeed highly unlikely given that the segmentation of clusters, and the ability to extract segments from within clusters, is generally a more demanding task than segmenting single consonants. It should additionally be noted that this finding holds for the control group and the dyslexic group equally: there was a group effect, with the control group having higher accuracy than the dyslexic group, but no interaction between group and number of consonants, and the higher accuracy in the biconsonantal items relative to the singleton items is characteristic of both the control group and the dyslexic group.

Further comment is required, finally, on the finding that for both groups, responses to the singleton and triconsonantal items were approximately equally accurate. The most likely explanation for why the three-consonant onsets were no harder than the singletons for the dyslexic group is that they (by definition, in English) all started with /s/. This would have meant that in the stimulus set as a whole, a disproportionate number of manipulations would have involved /s/ rather than any other initial onset consonant, potentially allowing participants to generalise the manipulation procedure for items beginning with /s-/ in a way that would not have been so straightforward for the singleton and bi-consonantal items, whose initial consonants could have been one of several possibilities (/p, b, d, k, f/, etc). What may have aggravated this issue is the fact that the particular types of foils which were provided for the tri-consonantal items may also have been easier to identify: they all happened to be of the 'cluster' and 'nonsegmentation' type, where either the whole onset cluster was moved to the end of the word (*atter-spley*, for *splatter*), or none of it was segmented at all (*splatter-ey*). This made the triconsonantal foils as a group different from the singleton and biconsonantal foils, which both consisted of either the 'addition' or the 'omission' type.

The outcomes of Pennington et al's (1990) study showed that although their yes/no judgment paradigm did elicit some differences between the control and dyslexic groups in their study, their production task, where participants have to pig latinise a given word and say it aloud, gave rise to more clear and consistent differences between the two groups. For the present study, since Pennington et al's results licensed the expectation that at least some group differences would be found from the judgment task, this was the paradigm that was used, in preference to the production task, partly to avoid potential difficulties with transcribing and scoring participants' responses (especially in the stress tasks, where it was envisaged that participants might not produce stress in a perceptually salient or reliable manner in an unfamiliar task such as this which might lead them to be less than confident in their productions, for example). There was also the further motivation that the judgment paradigm would keep the task demands as equivalent as possible throughout the battery of tasks which the participants took part in (that is, since both the Interpretation and Recognition tasks were forced-choice judgment tasks, tapping 'receptive' rather than 'expressive' language abilities, this characteristic was maintained in the manipulation tasks as well). The results of the present task therefore confirm that the judgment task can indeed be relied on to show up differences between dyslexic and control groups, even in adulthood.

4.6.3 The suprasegmental version of the Pig Latin task

According to the analysis presented in §4.5.1, the control group was more accurate than the dyslexic group in the suprasegmental Pig Latin task (there was no difference between the two groups in terms of response time). In terms of relating this finding to the various predictions which were made at the outset, these results are consistent only with the predictions of the narrow sense of the Phonological Deficit Hypothesis, the reading which suggests that it is only segmental phonological representations which are impaired in dyslexia and which would not therefore expect a deficit to be found in suprasegmental manipulation tasks. On the other hand, this result does not bear out the predictions of the 'broad reading' of the Phonological Deficit Hypothesis, nor indeed the view expressed in the Metalinguistic Hypothesis Chapter 1 that metalinguistic manipulation skills may be impaired across the board in dyslexia.

When the suprasegmental Pig Latin task was examined in more detail, the perplexing finding was made that there was an effect of item type in the accuracy data. Both groups were significantly more accurate in the items with SWW patterns (e.g. *'ca.len.dar*) than the items with WSW patterns (e.g. *dog.'ma.tic*). This result was not predicted in advance by any of the viewpoints under consideration, and it does not seem to have any direct bearing on the nature of the putative phonological deficit. Nor does it seem to have any straightforward explanation, in the sense that there is no obvious reason to expect trisyllabic words which happen to have a SWW pattern to be treated any differently from trisyllabic words which happen to have a WSW pattern.

However, examination of the items and foils showed that some factors were at play which could have made the SWW items easier than the WSW items. For instance, it may be the case that when the word's main stress is located at the very start of the word it is more salient than when it is located word-medially. It may also be the case that in items where main stress is moved rightwards in WSW words it ends up on the final syllable of a trisyllabic word, which may not be a very salient place for stress to be located; consider for example that final-stressed syllables in trisyllabic words are not necessarily very robust: words such as *magazine*, *barricade*, *thirteen*, etc, are typical candidates for stress shift in stress clash situations (compare ˌ*thir*ˈ*teen* with final stress in isolation, and ˈ*thir*ˌ*teen* ˈ*men*, a stress clash situation, where stress is moved leftwards so as to avoid two stressed syllables occurring adjacent to each other; see e.g. Giegerich (1992, §9.2.3.2), whose notation of primary and secondary stresses is followed here). It may be noted that this suggestion assumes that participants would treat the stress shift as a distinct step in the procedure affecting the trisyllabic form of the original word as such, rather than judging the acceptability of the four-syllable form of the output of the complete manipulation procedure. It may nevertheless be easier to identify a shift in stress from the initial syllable of a trisyllabic word to the second syllable of a four-syllable form than to identify a shift from the second syllable of a trisyllabic word to the third (or penultimate) syllable of a four-syllable word, since the former involves a move from the word edge into a medial position whereas the latter is a medial-to-medial move, which is likely to be more difficult to process. It should also be noted that, as was outlined in the materials section (§4.2.2), foils for both the SWW and WSW items included forms which had an unchanged stress pattern (e.g. *'ca.len.dar-ta* and *dog.'ma.tic-ta*). Since the task was explained as a task where stress should move from its location in the original word, these items in particular could have been easy enough to have skewed the results.

Clearly, the number of different kinds of foils which can be used in this task is limited by the nature of (English) word stress itself. In trisyllabic words there are only three possible locations for stress, and the motivation for including foils which had unchanged stress patterns was to provide a third type of foil in addition to the only other two possibilities (move stress two places towards the end of the word in SWW items and move stress to the start of the word in WSW items, given that the correct manipulation in this task was to move the stress one place towards the end). Foils with a greater or lesser number of syllables would not only be relatively easily identified and rejected, but would also bring additional difficulties in relation to the location of main stress and secondary stress or stresses, especially in forms with more than four syllables. However, it can be seen with hindsight that restricting the foil types to only these two would have avoided the difficulty that foils with unchanged stress patterns were too easy to identify.

4.7 Relation of Pig Latin performance to literacy measures

This section presents the results of correlating the segmental and suprasegmental versions of the Pig Latin task with WRAT Reading and Spelling measures. Results for the two groups are presented separately, the control group first followed by the dyslexic group, followed by a discussion of these results.

4.7.1 Correlating Pig Latin performance with WRAT measures

4.7.1.1 Results for the control group

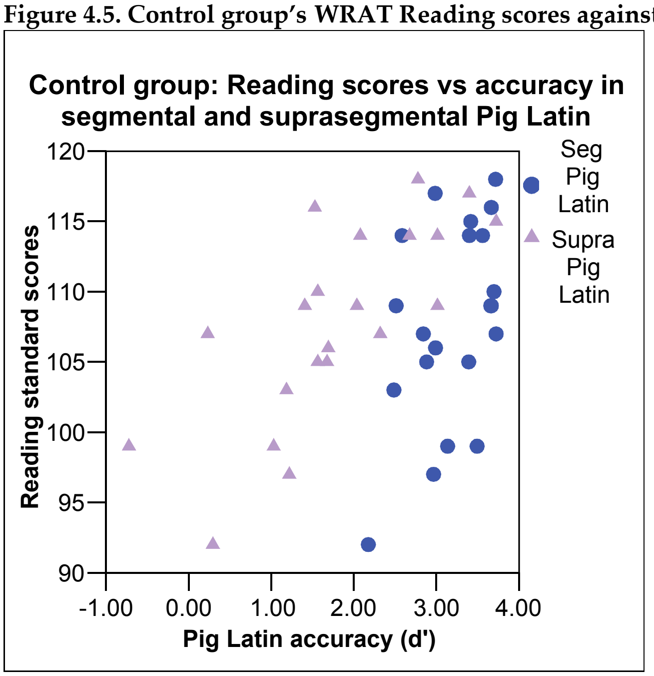
In the control group, accuracy on both versions of the Pig Latin task was correlated with WRAT Reading scores, although no relationship was found between Pig Latin accuracy and Spelling scores. The correlation coefficients are reported in Table 4.7.

Table 4.7. Correlation of controls' WRAT Reading and Spelling standard scores with accuracy in the Pig Latin task

	WRAT Reading	WRAT Spelling
Segmental Pig Latin (d')	$r = .452$ * $p = .040$ $n = 21$	$r = .008$ $p = .974$ $n = 21$
Suprasegmental Pig Latin (d')	$r = .748$ *** $p < .001$ $n = 21$	$r = -.125$ $p = .591$ $n = 21$

The scatterplot (Figure 4.5) shows WRAT Reading standard scores plotted against accuracy in the two versions of the Pig Latin task.

Figure 4.5. Control group's WRAT Reading scores against Pig Latin accuracy



The control group's WRAT Reading scores were not significantly correlated with their response times for either version of the Pig Latin task, and neither were their Spelling scores, as shown in Table 4.8.

Table 4.8. Correlation of controls' WRAT Reading and Spelling standard scores with response times in the Pig Latin task

	WRAT Reading	WRAT Spelling
Segmental Pig Latin (msec)	r = -.364 p = .105 n = 21	r = .113 p = .627 n = 21
Suprasegmental Pig Latin (msec)	r = .249 p = .277 n = 21	r = .172 p = .455 n = 21

The results of correlating the control group's performance on the Pig Latin task with the WRAT measures can therefore be summarised as showing a relationship between Reading and accuracy in both versions of the task.

4.7.1.2 Results for the dyslexic group

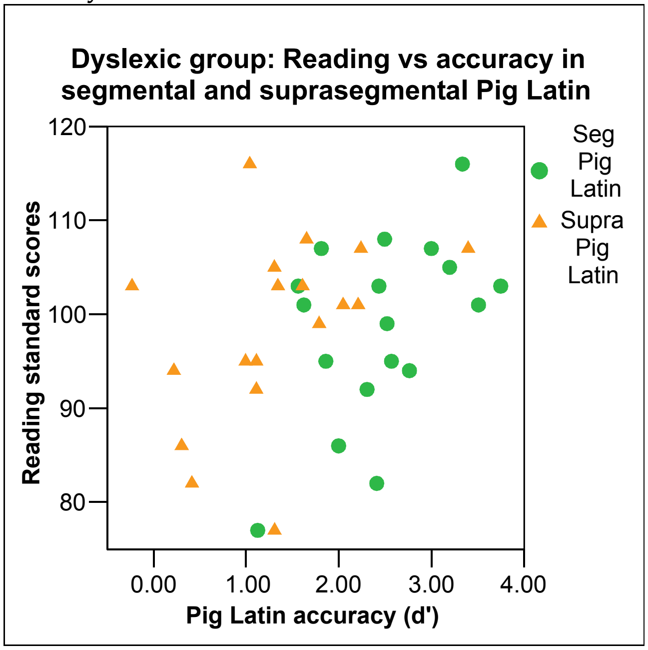
The correlation coefficients for the dyslexic group's accuracy on the WRAT measures and the Pig Latin task are shown in Table 4.9. There is a relationship between WRAT Reading and accuracy in the segmental Pig Latin task, and both WRAT Reading and Spelling are nearly significantly correlated with suprasegmental Pig Latin accuracy.

Table 4.9. Correlation of dyslexics' WRAT Reading and Spelling standard scores with accuracy in the Pig Latin task

	WRAT Reading	WRAT Spelling
Segmental Pig Latin (d')	r = .487 * p = .042 n = 18	r = .091 p = .718 n = 18
Suprasegmental Pig Latin (d')	r = .407 p = .094 n = 18	r = .424 p = .080 n = 18

Figure 4.6 below shows the relation between the dyslexic group's WRAT Reading performance and their accuracy in the segmental and suprasegmental versions of the Pig Latin task.

Figure 4.6. Dyslexic group's WRAT Reading scores against segmental Pig Latin accuracy



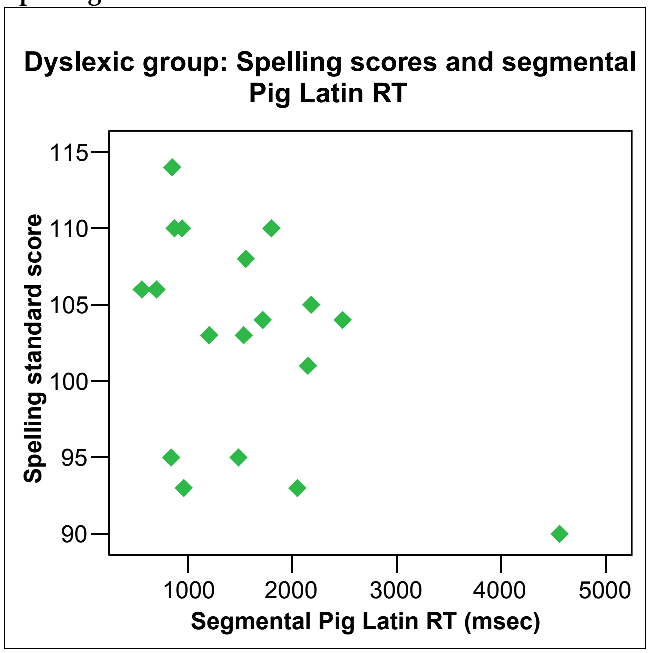
The results of correlating the WRAT scores of the dyslexic group with their response times for the Pig Latin task are shown in Table 4.10 below.

Table 4.10. Correlation of dyslexic group's WRAT Reading and Spelling standard scores with response times in the Pig Latin task

	WRAT Reading	WRAT Spelling
Segmental Pig Latin (msec)	r = -.148 p = .557 n = 18	r = -.462 p = .054 n = 18
Suprasegmental Pig Latin (msec)	r = .084 p = .739 n = 18	r = -.169 p = .502 n = 18

Although this table shows a nearly significant correlation between WRAT Spelling and response times to the segmental Pig Latin task, it can be seen from Figure 4.7 below that the mean response time of one participant is much longer than those of the rest of the group.[2] When this individual is excluded from the analysis, the correlation is no longer significant (r = -.180, p = .489).

Figure 4.7. Dyslexic group's segmental Pig Latin response times against WRAT Spelling scores



In summary for the dyslexic group, while the clearest relationship is found between accuracy in the segmental Pig Latin task and their Reading scores, there is a nearly significant relationship between their suprasegmental accuracy and scores on both the WRAT subtasks.

[2] Note that removing this individual from the analysis does not substantially affect the outcome of the analyses reported in §4.5, either in terms of the comparison between the segmental and suprasegmental domains in the Pig Latin task or in terms of the details of the segmental Pig Latin task.

4.7.2 Discussion of the relationship between the Pig Latin task and literacy measures

In their study of adults with dyslexia, Gottardo et al (1997) found a significant correlation between segmental Pig Latin accuracy and WRAT Reading. This result was replicated in the present study: there was a moderate, significant correlation between segmental Pig Latin accuracy and WRAT Reading for both the control group and the dyslexic group.

In terms of the question of phonological domains, for the control group the relationships tended to hold the Reading measure and between accuracy in either domain. For the dyslexic group, there was a significant correlation between segmental accuracy and Reading, while accuracy in the suprasegmental version of the task was nearly significantly correlated with both the literacy measures. Although there is no theoretical perspective which relies on a particularly close link between reading success and the ability to manipulate stress patterns, this finding adds to the evidence that broader language-related skills, including those which draw on suprasegmental aspects of spoken language, may bear some relation to literacy skills.

4.8 Conclusions arising from the Pig Latin task

The question which this chapter was particularly intended to address is whether the deficits in segmental Pig Latin manipulation skills which have previously been found in other studies of adults with developmental dyslexia would also be found in suprasegmental manipulation tasks – that is, when the phonological units involved in the manipulation are suprasegmental. Although this study replicated the finding that individuals with dyslexia show a deficit in segmental Pig Latin manipulation tasks relative to controls (Pennington et al 1990, Gottardo et al 1997), no difference was found between the groups in the suprasegmental version of the task.

Again these results can be taken as consistent with the predictions of the 'narrow' reading of the Phonological Deficit Hypothesis: a hypothesised impairment of only segmental representations does not predict a deficit in the manipulation of suprasegmental units. They would not be consistent with the 'broad' reading of the Phonological Deficit Hypothesis, since a hypothesised deficit in suprasegmental representations would be expected to manifest itself in suprasegmental manipulation tasks in the same way as segmental representations are taken to be related to segmental manipulation performance. Additionally, when the two groups' Pig Latin performance was correlated with the literacy measures, the correlation between the segmental version and the WRAT measures was statistically significant for both groups, a finding which replicates what was reported by Gottardo et al (1997) for adults with dyslexia. The relationship between suprasegmental accuracy and Reading (which was significant for the control group and nearly significant for the dyslexic group), is consistent with both the 'narrow' and the 'broad' interpretations of the Phonological Deficit Hypothesis and also with the view that metaphonological skills in general are related to reading.

For this task a couple of unexpected patterns of performance were uncovered in the two versions of the task. In the segmental version, although the two groups differed in the predicted directions in both accuracy and response time (with the dyslexic group finding the task harder than the control group), they inexplicably found the manipulation easier when the consonant was moved from a biconsonantal cluster than when it was a singleton. Meanwhile in the suprasegmental version, no explanation was readily available for why the two groups' success in correctly rejecting SWW foils of the *'badminton*, *'badminton-ta* type was greater than for WSW foils of the *ca'thedral*, *ca'thedral-ta* type. However, as already mentioned, these effects do not have any direct bearing on the difference between the two groups.

Having now seen the outcomes of three tasks, the following chapter will report on the fourth and final task of the present study, one which like the Pig Latin task involves the manipulation of phonological units, but with the extra factor that more than one unit is manipulated at a time.

Chapter 5

The Spoonerism task

5.1 Introduction

It was seen in Chapter 4 that in the Pig Latin task, the group of individuals with dyslexia showed a deficit relative to the control participants in manipulating the required unit in the segmental version of the task, but not in the suprasegmental version. This chapter reports the Spoonerism task, the fourth and final task which was administered to the participants in this study. The motivation behind this task was similar in several respects to the motivation for the Pig Latin task: given that adults with dyslexia show deficits relative to controls in segmental spoonerism tasks, the question which the use of this task aims to address is whether a deficit will also be shown in these participants with dyslexia when the manipulation is suprasegmental.

In the Spoonerism task, participants were required to identify two comparable phonological units within a pair of words presented together, and isolate these units from their original environment before exchanging them to create new forms of the original words. To an even greater extent than in the Pig Latin task, the Spoonerism task included demands on working memory, but the most common interpretation of the results of spoonerism tasks in the literature is that they reflect phonological awareness skills (Snowling et al 1997), and the key point of interest in the present study was whether any difference would appear between the performance of the control group and the dyslexic group in the segmental and suprasegmental versions of this task.

In a way similar to the Pig Latin task, the predictions of the Phonological Deficit Hypothesis in relation to the Spoonerism task can be read in two ways: either in its broad reading, as predicting a suprasegmental manipulation deficit in the Spoonerism task, or else, in its narrow reading, as predicting no such deficit. In keeping with the argument presented in Chapter 1, where the distinction between implicit knowledge and metalinguistic skills is assumed to be more important than the distinction between segmental and suprasegmental areas of phonology, it is expected that a deficit will be apparent in the group of individuals with dyslexia in both the segmental and suprasegmental versions of this task.

The materials which were used in this task are presented first of all in this chapter, for both the segmental version (§5.2.1) and the suprasegmental version (§5.2.2) of the task. The individuals who took part in this task are the same as those who took part in the previous three tasks (§5.3). Subsequently a description of the experimental procedure is provided in §5.4, and the results are presented in §5.5. A discussion is presented in §5.6, following the same order of the overall comparison between the segmental and suprasegmental versions, then each of these versions in turn.

As was done previously, the performance of the two groups in the manipulation tasks are correlated with their performance in the WRAT literacy tests. These correlations are reported in §5.7. Again, the purpose of this analysis is to confirm that the skills being tapped by the tasks devised for this study bear the same kind of relation to standard measures of literacy proficiency as tasks which are known from existing studies to be predictive of literacy ability. In their study of university students with dyslexia, Ramus et al (2003) found that a general measure of phonology, which included a spoonerism task, was a very good predictor of the literacy measure (which included the WRAT subtasks), and some link was also found by Judge, Caravolas, and Knox (2006) between a spoonerism task and WRAT Reading in adults with dyslexia. Given these findings for conventional segmental versions of very similar tasks to the ones used in the present study, it is expected that the segmental versions of the Spoonerism task in this study will be correlated with the WRAT measures, and the main focus of interest in this section is therefore whether performance in the suprasegmental version will also be correlated with literacy performance.

5.2 Spoonerism materials

5.2.1 Materials for segmental Spoonerism task

The items consisted of 22 pairs of bisyllabic words. Half the pairs consisted of words beginning with singleton consonants, and half with biconsonantal clusters. The complete stimulus list is provided in Appendix E.

To create a spoonerism, the initial consonant of both words should be exchanged, leaving the remainder of the words intact. For example, the pair *plastic*, *craggy* would become *clastic*, *praggy* (and the pair *hamster*, *signal* would become *samster*, *hignal*). Note that again, strictly only the first consonant in the onset is affected in the manipulation, not the whole onset.

Half the items were correctly spoonerised and half were matched with a foil. There were three types of foil: one where only one consonant was swapped (*plastic*, *praggy*), one where the whole cluster was swapped (*crastic*, *plaggy*), and one where the whole syllable was swapped (*hamnal*, *sigster*).

5.2.2 Materials for suprasegmental Spoonerism task

The items consisted of 23 pairs of trisyllabic words. Each pair consisted of one word with a SWW stress pattern and one with a WSW pattern. The complete stimulus list is provided in Appendix E.

Again, the suprasegmental version was based as closely as possible on the segmental version. To create a spoonerism, the location of the main stress in the words had to be exchanged. For example, the pair *ca.'the.dral*, *'bad.min.ton* would become *'ca.the.dral*, *bad.'min.ton*. This procedure retained the key features of the segmental Spoonerism task: equivalent elements had to be identified in both the words in the pair presented, and these elements had to be exchanged, with the difference being that in this task it was the location of the main stress rather than a particular consonant identified on the basis of its location in the word. It can be noted that an equivalent way of considering this manipulation would be to say that it was the stress *pattern* that was swapped, i.e. the whole template SWW for WSW or vice versa: but the parallel with the segmental version of the task can be more clearly seen when it is described in terms of 'the location of the main stress.'

Half the items were correctly spoonerised and half were given a foil. There were two types of foil: in both types of foil, one of the items had its stress shifted appropriately, but in addition, in one foil type the stress remained in the same place on the other item (e.g. *'ca.the.dral*, *'bad.min.ton*), and in the other foil type, the stress moved to the end of the item (e.g. *'ca.the.dral*, *bad.min.'ton*). Note that although these examples show the first word in the pair with stress correctly shifted, there were equal numbers of instances of correct stress in the first and in the second word in the pair.

5.3 Participants

The same individuals as participated in the previous tasks also participated in this Spoonerism task; the participant information was provided in §2.3, and complete participant details are given in Appendix A.

5.4 Procedure for Spoonerism task

As before, participants were tested individually and the order of tasks was alternated between participants depending also on the order of the Pig Latin task, as was explained in Chapter 4 (§4.4). Auditory stimuli were again played through headphones, and participants made their response using specified keys on the keyboard. They were given as much time as they needed to make their response and there was a pause of one second after the participant's response before the start of the next trial.

Clear and detailed instructions about the spoonerism manipulation were provided verbally to each participant prior to them taking part in the task, along with either one or two practice items. Each participant expressed that they understood the manipulation procedure before they went on to begin the task. Again, all the instructions and examples for the Spoonerism task were always given in terms of 'sounds' ('the very first sound in the word') – the examples were verbal, and no written examples were provided in the on-screen instructions presented by E-Prime.

Full instructions for the two versions of the Spoonerism task are provided in Appendix E.

For both versions of the Spoonerism task, participants heard the pair of original words followed by a manipulation of those words. There was an interval of 500 msec between the items in each pair and before the manipulation was played. Participants were instructed to state whether the manipulation they heard was correct or not, in terms of the description they had practiced. After the stimuli were played, participants were shown a screen containing the word “yes” presented on the left hand side of the screen and “no” on the right hand side. It may be noted again that the participants were not required to produce the manipulation; rather their task was to judge whether the manipulation was a correct spoonerism, responding ‘yes’ or ‘no’ accordingly.

5.5 Results of the Spoonerism tasks

As before, both accuracy and reaction time data were collected for each task.

Accuracy was measured using the d' calculation which is appropriate for Yes-No experiments (as was described in the previous chapter, §4.5) (Macmillan & Creelman 2005). The same procedure was used as before for dealing with proportions of 0 and 1 in the calculation of d' (see §2.5).

Response time was again measured in milliseconds (for correct responses only). As before, for each participant, response times which were longer or shorter than 2 standard deviations from his or her mean response time were excluded from the analysis, along with the corresponding ‘yes/no’ decision.

5.5.1 Overall Spoonerism results

This task aimed to test whether participants could exchange units in pairs of words. Again, like in the Pig Latin tasks, the units in question were either the words' initial onset consonants (e.g. /k/ and /p/ in *clinic* and *prison*), or the location of the main stress in the words (such as *ca.ˈthe.dral*, *'bad.min.ton*). In line with previous findings (e.g. Snowling et al 1997), and as predicted by the Phonological Deficit Hypothesis, it was expected that the controls would outperform the dyslexics on the segmental version. If the known manipulation deficit extended to suprasegmental areas of phonology too then the dyslexics were expected to show a deficit in the stress task too.

Table 5.1 shows the accuracy figures for both groups in the segmental and suprasegmental versions of the Spoonerism task. For information, accuracy expressed as percentages was as follows: in the segmental version, 87.7% for the control group and 74.0% for the dyslexic group; in the suprasegmental version, 84.5% for the control group and 68.0% for the dyslexic group.[1]

Table 5.1. Accuracy (*d'*) for the segmental and suprasegmental versions of the Spoonerism task

	Segmental: mean (sd)	Suprasegmental: mean (sd)
Control	2.40 (0.56)	2.21 (1.03)
Dyslexic	1.41 (0.98)	1.09 (1.27)

A 2x2 mixed ANOVA was carried out, with accuracy as the dependent variable, phonological Domain as the within-subjects factor, and Group as the between-subjects factor. There was a significant main effect of Group, with higher accuracy in the control group ($F(1, 39) = 15.632$, $p < .001$). There was no effect for Domain

[1] Kolomogorov-Smirnov tests confirm that there were no ceiling effects in either version of this task, for either group.

($F(1, 39) = 2.833$, $p = .100$). There was no interaction ($F(1, 39) = .170$, $p = .682$). This is shown in Figure 5.1 below.

Figure 5.1. Accuracy in both versions of the Spoonerism task (segmental vs suprasegmental)

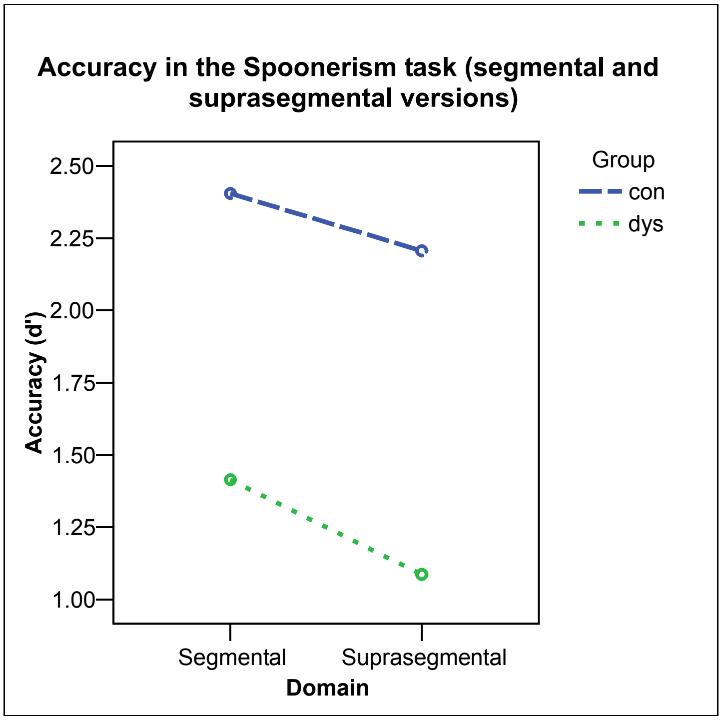


Table 5.2 shows the response time figures for both groups in the segmental and suprasegmental versions of the Spoonerism task.

Table 5.2. Response time (msec) for the segmental and suprasegmental versions of the Spoonerism task

	Segmental: mean (sd)	Suprasegmental: mean (sd)
Control	1884.7 (1148.7)	1772.5 (1154.7)
Dyslexic	1698.4 (967.7)	1581.5 (1490.2)

A 2x2 mixed ANOVA was carried out, with RT as the dependent variable, phonological Domain as the within-subjects factor and Group as the between-subjects factor. There was no significant effect for Group (F(1, 39) = .522, p = .474), or for Domain, although there were longer response times for the suprasegmental items compared to the segmental items (F(1, 39) = 0.179, p = .675). There was no interaction (F(1, 39) < .001, p = .993).

5.5.2 Results of the segment-based Spoonerism task

To investigate the segmental Spoonerism task in more detail, recall that the words in half the pairs began with a singleton consonant, and in the other half they began with a two-consonant cluster. It was expected (on the basis of existing findings of a persisting deficit in phoneme manipulation, e.g. Bruck (1992), and as predicted by the Phonological Deficit Hypothesis) that the dyslexic group would have greater difficulty in the second type of item, i.e. where they had to extract the consonant from a cluster.

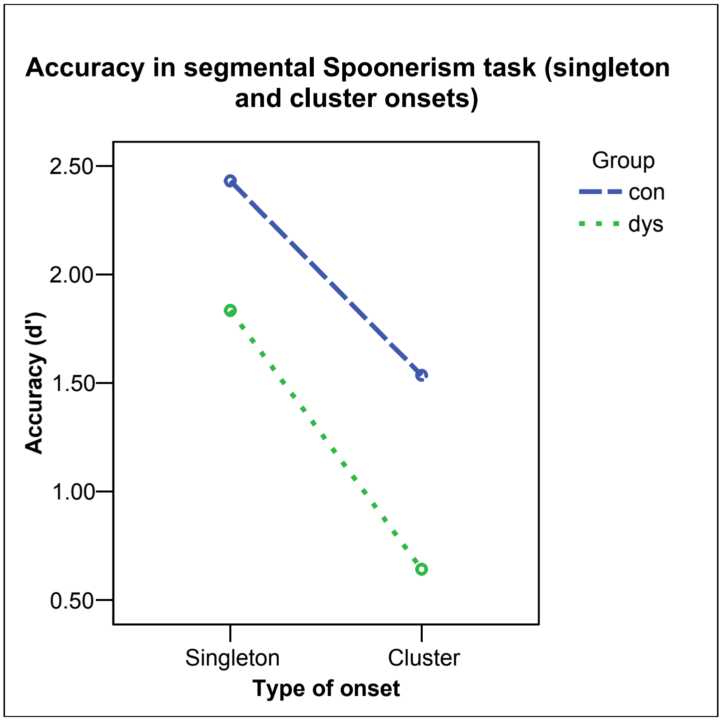
Accuracy scores are presented in Table 5.3.

Table 5.3. Accuracy (*d'*) for singleton and cluster onsets in the segmental Spoonerism task

	Singleton: mean (sd)	**Cluster: mean (sd)**
Control	2.43 (0.42)	1.54 (0.65)
Dyslexic	1.83 (0.87)	0.64 (1.02)

A 2x2 mixed ANOVA was run on the accuracy data, with Cluster (singleton, biconsonantal) as the within-subjects factor and Group as the between-subjects factor. There was a significant main effect of Group, with controls significantly more accurate than dyslexics (F(1, 40) = 13.297, p = .001). There was also a significant main effect of Cluster, with significantly lower accuracy in the bi-consonantal items compared to the singleton items (F(1, 40) = 71.122, p < .001). Although the dyslexics showed lower accuracy than the controls in the bi-consonantal condition, this interaction was not significant ($F(1, 40) = 1.437$, $p = .238$).

Figure 5.2. Accuracy in the segmental Spoonerism task (singleton and cluster onsets)



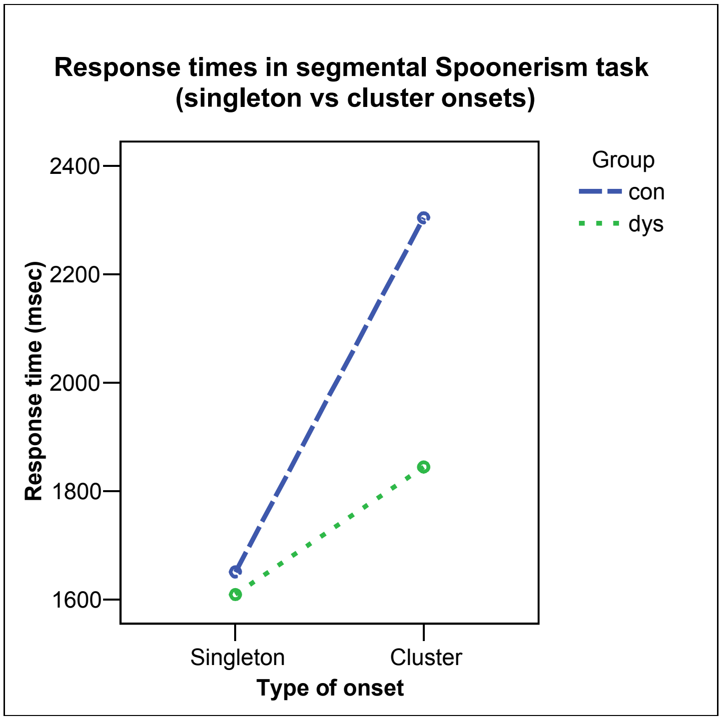
The response times are shown in Table 5.4.

Table 5.4. Response times (msec) for singleton and cluster onsets in the segmental Spoonerism task

	Singleton: mean (sd)	Cluster: mean (sd)
Control	1650.8 (1101.2)	2304.0 (1351.2)
Dyslexic	1609.2 (935.2)	1844.4 (1247.7)

A 2x2 mixed ANOVA with RT as the dependent variable showed no effect of Group ($F(1, 40) = .545$, $p = .465$). There was however a significant main effect of Cluster, with longer response times in the biconsonantal items compared to the singleton items ($F(1, 40) = 13.069$, $p = .001$). The response times of the dyslexic group were shorter than those of the control group in the biconsonantal items, but this interaction did not reach significance ($F(1, 40) = 2.894$, $p = .097$). See Figure 5.3.

Figure 5.3. Response times in the segmental Spoonerism task (singleton vs cluster onsets)



5.5.3 Results of the suprasegmental Spoonerism task

The only within-task variable in the suprasegmental Spoonerism task was the order of presentation of the words to be manipulated, i.e. whether the item with the SWW pattern came before the item with the WSW pattern (*'fic.tio.nal*, *pre.'ten.der*), or vice versa (*ca.'the.dral*, *'bad.min.ton*). There was no reason to expect that one or the other pattern would be more difficult for either group, and this was confirmed in the lack of an effect of presentation order in both the accuracy and the response time measures.

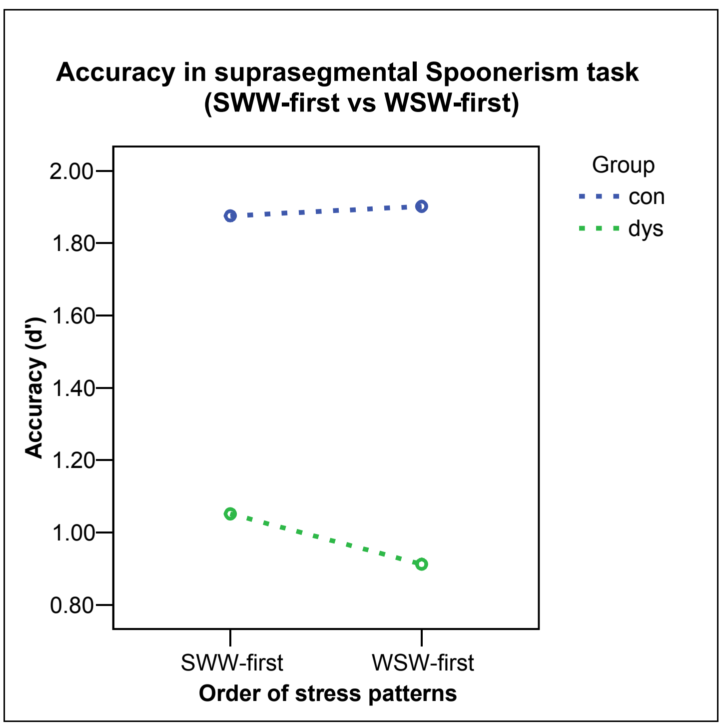
The accuracy data is shown in Table 5.5.

Table 5.5. Accuracy (*d'*) for two item presentation orders (SWW before WSW, and WSW before SWW) in the suprasegmental Spoonerism task

	SWW first: mean (sd)	WSW first: mean (sd)
Control	1.88 (0.81)	1.90 (0.79)
Dyslexic	1.05 (1.52)	0.91 (0.96)

A 2x2 mixed ANOVA (with accuracy as the dependent variable, Order (SWW-first, WSW-first) as the within-subjects factor, and Group as the between-subjects factor) showed that there was a significant effect of Group ($F(1, 39) = 9.272$, $p = .004$) but no effect of Order ($F(1, 39) = .158$, $p = .694$) and no interaction ($F(1, 39) = .338$, $p = .564$). This is graphed in Figure 5.4.

Figure 5.4. Accuracy in the suprasegmental Spoonerism task (SWW-first vs WSW-first)



The response time figures are shown in Table 5.6.

Table 5.6. Response time (msec) for two item presentation orders (SWW before WSW, and WSW before SWW) in the suprasegmental Spoonerism task

	SWW first: mean (sd)	WSW first: mean (sd)
Control	1753.2 (1799.3)	1548.6 (1194.0)
Dyslexic	1798.0 (1422.2)	1618.9 (996.6)

A 2x2 mixed ANOVA with RT as the dependent variable, Group as the between-subjects variable, and Order as the within-subjects variable, showed that there was no effect of Group ($F(1, 39) = .020$, $p = .888$), no effect of Order ($F(1, 39) = 1.250$, $p = .270$), and no interaction ($F(1, 39) = .006$, $p = .941$).

5.6 Discussion of Spoonerism results

5.6.1 *Overall Spoonerism results: manipulations involving two phonological units*

The purpose of the Spoonerism task was to examine the manipulation skills of the groups of participants when two phonological units were required to be manipulated at once. For the segmental version this required the initial consonant to be exchanged in a pair of words (e.g. *plastic*, *craggy* becomes *clastic*, *praggy*), and for the suprasegmental version, the location of the main stress had to be exchanged in a pair of words (e.g. *ca.'the.dral*, *'bad.min.ton* becomes *'ca.the.dral*, *bad.'min.ton*).

What the Spoonerism task had in common with the Pig Latin task was the requirement to manipulate particular phonological units – that is, to identify, isolate, and extract a specified unit and put it to use in an arbitrary procedure. The output of the manipulation procedure bore some systematic resemblances to the original word which was manipulated, but the meanings of the words either as citation forms or in discourse contexts was irrelevant to the task, as participants had to analyse only the form of the words. Where the Spoonerism task differed from the Pig Latin task was in the fact that it required the manipulation of two units rather than one – there were two original words, and corresponding units had to be identified in each of them, and manipulated. The segmentation demands of this task were therefore greater than they were in the Pig Latin task ('segmentation' in terms of isolating the unit in question, whether consonantal or suprasegmental), as two words needed to be analysed at the same time. Additionally, working memory demands were also fairly substantial in the Spoonerism task, certainly relative to the other three tasks in this study, again since two words had to be held, analysed, segmented, and modified simultaneously.

The results of the Spoonerism task bore out the prediction that the group of individuals with dyslexia would find it harder than the group of control participants: the accuracy of the control group's responses was found to be significantly higher than the accuracy of the dyslexic group. It was also found that a deficit does appear in the dyslexic group when suprasegmental units are required to be manipulated, as well as when the units are segmental. That is, the accuracy of the dyslexics was impaired relative to the controls on the Spoonerism task, whether the phonological manipulation involved segments or stress. The finding of a difference between the groups corroborates what has been found in other studies of adults with dyslexia (e.g. Snowling et al 1997) and it also extends the findings of existing studies, which have focused on the manipulation of segments, by showing that the manipulation of suprasegmental elements of words can also be impaired in dyslexia, given the appropriate task. In the following two subsections, this general finding will be elaborated on in more detail, by looking at the performance of the two groups first in the segmental version of this task and then in the suprasegmental version. Chapter 6 will include a discussion of what properties of the spoonerism procedure might have made it more difficult for individuals with dyslexia than the individuals in the control group, since in the light of the Pig Latin results it seems that it may not be the manipulation demands alone which bring out the difference between the two groups of participants.

Interestingly, however, unlike in the other three tasks, there was no effect for phonological domain in the Spoonerism task – the suprasegmental version was no harder than the segmental version (whether performance was measured in terms of response time or accuracy). In general, it would not have been unexpected if the suprasegmental version had been harder than the segmental version: just as in the previous tasks, it could have been expected that the suprasegmental version would be harder than the segmental version, for the same reasons connected with lack of familiarity with stress and stress patterns in English and the reduced salience of stress relative to segments, and so on. This means that the significant main effect of phonological domain in the Interpretation, Recognition, and Pig Latin tasks is unsurprising, and it is the results of the Spoonerism task which require further comment. From looking at the control group's accuracy results in the Spoonerism task in conjunction with their accuracy in the Pig Latin task, it would seem that the stress version of the Spoonerism task was relatively easy (suprasegmental Spoonerism $d' = 2.21$, suprasegmental Pig Latin $d' = 1.80$), while the segmental version was relatively difficult (segmental Spoonerism $d' = 2.40$, segmental Pig Latin $d' = 3.70$). The accuracy of the dyslexic group also suggests that the segmental Spoonerism task ($d' = 1.47$) was harder then the segmental Pig Latin task ($d' = 3.52$), while the suprasegmental Spoonerism task was easier (suprasegmental Spoonerism $d' = 1.09$, suprasegmental Pig Latin $d' = 1.40$). It is possible that in the Spoonerism task, the segmental version was particularly difficult due to the requirement not only to identify the segment to be exchanged but to modify the original words themselves: in the segmental Pig Latin task, the modification of the original word was limited to affixing additional material consistently to the vowel /e/ at the end of the word, whereas in the segmental Spoonerism task the original word had to be kept in mind to the extent of not only extracting its first segment but replacing it with a different segment on a word-by-word basis. What may have made the suprasegmental Spoonerism task relatively easy was the fact that all the correct items consisted of a pair of forms, one of which had SWW stress and the other WSW. In addition, although the raw number of syllables which participants had to deal with on any given trial was fairly high (three syllables in each of the original words in the pair and the manipulated forms), this was not so relevant to the task as the stress patterns on each word – one main stress per word, or one stress pattern per word. A broader consideration of the construction of the foil items in this task will also be outlined in §5.6.3, where the results of the suprasegmental version of this task are discussed in more detail.

5.6.2 The segmental version of the Spoonerism task

In line with the findings of existing studies (such as those undertaken with adults by Snowling et al (1997) and Hatcher et al (2002)), these participants with dyslexia were found to have weaker performance than non-dyslexic controls in the segmental Spoonerism task, in particular in terms of accuracy.

When the performance of the groups was examined according to whether the items to be manipulated had biconsonantal onsets (such as *plastic*, *craggy*) or singleton onsets (e.g. *hamster*, *signal*), it was found that both groups found the biconsonantal items harder than the singleton items, both in terms of lower accuracy and higher response times, but there was no interaction of clusters with group, even though the group with dyslexia might have been expected to perform less successfully when they were required to extract consonants from clusters rather than as singletons. It is not, therefore, a problem with segmentation as such that differentiates the two groups, since extracting consonants from clusters was harder for both groups than was moving singleton consonants. The performance of the groups on the singleton and biconsonantal onsets in the segmental Spoonerism task was, additionally, the direct opposite of their behaviour in the segmental Pig Latin task, where their accuracy was much higher in the biconsonantal items. As was discussed in the previous chapter in relation to the segmental Pig Latin task (§4.6.2), there seems to be no clear reason why the biconsonantal items in the Pig Latin task should have elicited this performance. The expectation on the basis of the existing literature is straightforwardly that cluster segmentation should be more challenging than the isolation of singleton consonants (perhaps particularly so for individuals with dyslexia, as suggested by Bruck & Treiman (1990), Fawcett & Nicolson (1995), and Pennington et al (1990), yet this was not the finding of the present study). The results of the segmental Spoonerism task therefore, to a greater extent than the results of the segmental Pig Latin task, fit well with the existing literature: the dyslexic group found it harder to manipulate segments in general, and confirms what has been argued in previous studies, that even as adults, immersed in an environment which demands a more or less constant high degree of literacy competence, individuals with dyslexia are still characterised by a difficulty in manipulating segments in this way.

Finally, it may be noted that when Gallagher et al (1996) examined the phonological skills of 18 year olds with dyslexia, the results of their segmental spoonerism task showed that the dyslexic participants did not differ from the control participants in accuracy, but there were longer response times in the dyslexic group than the control group. The other studies which have found differences between adults with and without dyslexia in spoonerism tasks have tended to show differences in both accuracy and response time (Snowling et al 1997, Hatcher et al 2002, Ramus et al 2003, and in the small sample in Brunswick et al 1999; in Judge et al 2006 only accuracy results are reported). It is possible that the response time difference may have emerged due to the need for participants to produce the spoonerised forms aloud themselves, whereas in the present study the participants were merely required to judge whether the presented form was the correct spoonerism or not.

5.6.3 The suprasegmental version of the Spoonerism task

In the suprasegmental version of the Spoonerism task, a significant difference was found between the two groups in the accuracy data, with the control group performing with higher accuracy than the dyslexic group. In conjunction with the finding that the dyslexic group's performance was also weaker on the segmental version of this task, the finding of a deficit in the suprasegmental version provides evidence that, under certain conditions, the ability of individuals with dyslexia to manipulate the suprasegmental elements of words can also be impaired in addition to their known deficit in the manipulation of segmental elements. The results of the suprasegmental Pig Latin task are what make it necessary to include the caveat 'under certain conditions,' and it will be discussed further in Chapter 6 what these conditions might consist of.

This result is consistent both with the 'broad' reading of the Phonological Deficit Hypothesis, which predicts that both segmental and suprasegmental phonological representations are impaired and will give rise to manipulation deficits, and also with the view which sees metalinguistic manipulation skills as likely to be impaired across the board as a product of the difficulty of metalinguistic analysis, rather than as an effect of impaired representations. By this point it can be seen that when the results of all four tasks are taken at face value, some support is found not only for the position advanced in Chapter 1 but also for both the broad and the narrow readings of the Phonological Deficit Hypothesis. For the time being, the fact that the two alternative accounts can both find support in the results of the suprasegmental Spoonerism task will simply be noted, and will be discussed further in Chapter 6.

Two points arising from the materials of the suprasegmental Spoonerism task can be noted in conclusion. Firstly, as was outlined in §5.2.2, the only within-task variable in the suprasegmental Spoonerism task was the order of presentation: the two words to manipulated were presented either in the order SWW before WSW, or else WSW before SWW. Since the task required only that the locations of the main stress should be swapped, there was no reason to expect that either sequence of stress patterns would be harder or easier than the other (for either group). The results bore out this expectation – no effect of presentation order was seen either in the accuracy data or the response time data.

Secondly and finally, the construction of the foils could have given rise to concern that some trials might have been easier than others. This possibility arises from the fact that in half the foils, one of the items in the pair was given its original stress pattern rather than a modified (wrong) stress pattern (for example, whereas the correct spoonerism for *ca'the.dral*, *'bad.min.ton* would have been *'ca.the.dral*, *bad'min.ton*, this kind of foil would have consisted of one of the items with the correctly modified stress pattern and the other with its stress pattern unchanged, i.e. either *'cathedral*, *'badminton* or *ca'thedral*, *bad'min.ton*). Since the point of the spoonerism modification was to exchange the stress pattern, leaving one of the items with its stress pattern unchanged entails that both the forms in the modification have the same stress pattern, a characteristic which could have allowed participants to develop a strategic response pattern, in which rejecting modifications where both items had the same stress pattern would have resulted in an accurate response for a quarter of the items in this task. A similar strategy would have been slightly more difficult to apply in the other type of foil, the 'end-stress' type, where both items had a changed stress pattern, one with the correct pattern and the other with end stress (i.e. either *ca'the.dral*, *bad.min'ton*, or *ca.the'dral*, *'bad.min.ton*). The only possible strategy for this foil type would have been to reject any stimulus where either of the modified forms had word-final stress, regardless of the stress pattern of the other item in the pair. However, an examination of participants' accuracy in the two types of foil shows that accuracy levels were equivalent in both foil types. The control group responded correctly to 75% of the 'same-stress' foils and 84% of the 'end-stress' foils, while the dyslexic group responded correctly to 65% of the 'same-stress' foils and 63% of the 'end-stress' foils.

5.7 Relation of Spoonerism performance to literacy measures

This section presents the results of correlating the segmental and suprasegmental versions of the Spoonerism task with WRAT Reading and Spelling measures. Results for the two groups are presented separately, the control group first followed by the dyslexic group, followed by a discussion of these results.

5.7.1 Correlating Spoonerism performance with WRAT measures

5.7.1.1 Results for the control group

In the control group, accuracy on the suprasegmental Spoonerism task was significantly correlated with WRAT Reading scores, where high Reading scores were associated with high accuracy, and the correlation between Reading and segmental accuracy approached significance. Additionally, Spelling was significantly correlated with the segmental task, although in this instance the correlation was negative, indicating that lower Spelling scores are associated with higher segmental accuracy for this group. The values are shown in Table 5.7.

Table 5.7. Correlation of control group's WRAT Reading and Spelling standard scores with accuracy in the two manipulation tasks

	WRAT Reading	WRAT Spelling
Segmental Spoonerism(d')	r = .381 p = .089 n = 21	r = -.533 * p = .013 n = 21
Suprasegmental Spoonerism (d')	r = .525 * p = .015 n = 21	r = -.286 p = .209 n = 21

Figure 5.5 shows the control group's WRAT Reading standard scores plotted against accuracy in the two versions of both the Spoonerism task.

Figure 5.5. Control group's WRAT Reading scores against segmental and suprasegmental Spoonerism accuracy

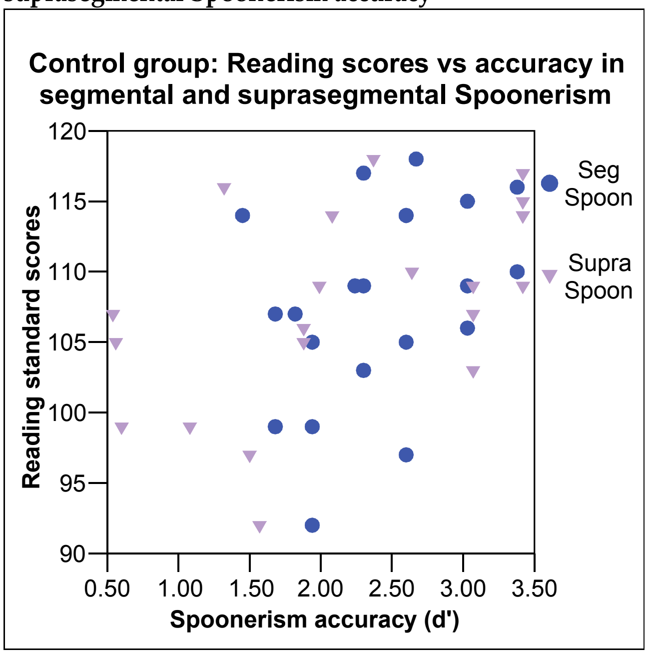
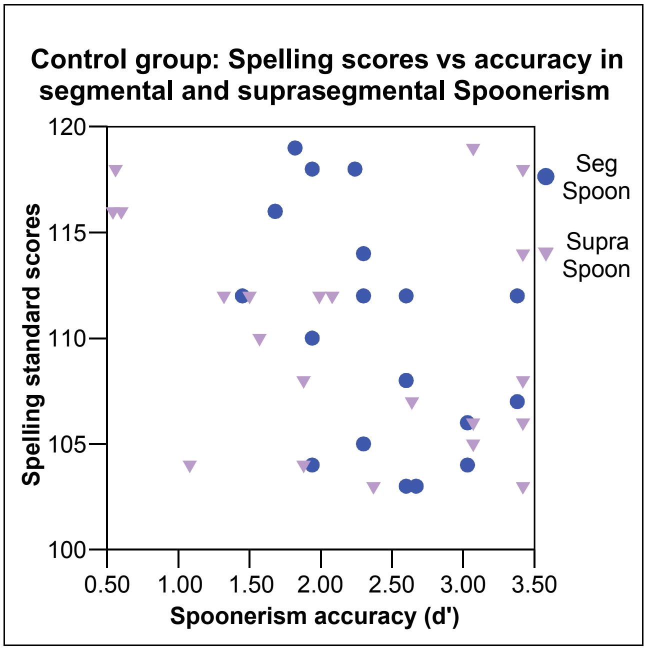


Figure 5.6 on the following page shows the control group's WRAT Spelling scores plotted against Spoonerism accuracy.

Figure 5.6. Control group's WRAT Spelling scores against segmental and suprasegmental Spoonerism accuracy



Neither Reading nor Spelling scores are significantly correlated with response times for either version of the Spoonerism task for the control group, as shown in Table 5.8.

Table 5.8. Correlation of control group's WRAT Reading and Spelling standard scores with response times in the two manipulation tasks

	WRAT Reading	WRAT Spelling
Segmental Spoonerism (msec)	r = .005 p = .983 n = 21	r = .314 p = .166 n = 21
Suprasegmental Spoonerism (msec)	r = .214 p = .352 n = 21	r = -.143 p = .536 n = 21

The results of correlating the control group's performance on the manipulation tasks with the WRAT measures can therefore be summarised as showing a relationship between one or the other of the WRAT measures and accuracy in one or the other version of the Spoonerism task. These relationships were evident only in the accuracy data; response times were not related to literacy.

5.7.1.2 Results for the dyslexic group

The correlation coefficients for the dyslexic group's accuracy on the WRAT measures and the two versions of the Spoonerism task are shown in Table 5.9. There is a significant correlation between both WRAT Reading and Spelling performance and accuracy in the two versions of the Spoonerism task, although this finding for the suprasegmental version will be qualified below (in relation to Figure 5.8).

Table 5.9. Correlation of dyslexic group's WRAT Reading and Spelling standard scores with accuracy in the two manipulation tasks

	WRAT Reading	**WRAT Spelling**
Segmental Spoonerism(*d′*)	r = .705 ** p = .001 n = 19	r = .762 *** p < .001 n = 19
Suprasegmental Spoonerism (*d′*)	r = .475 * p = .046 n = 19	r = .600 ** p = .008 n = 18

The dyslexic group's WRAT Reading performance and accuracy in the segmental versions of the two tasks is shown in Figure 5.7 (on the following page), where it can be seen that higher Spoonerism accuracy is associated with higher Reading scores.

Figure 5.7. Dyslexic group's WRAT Reading scores against segmental and suprasegmental Spoonerism accuracy

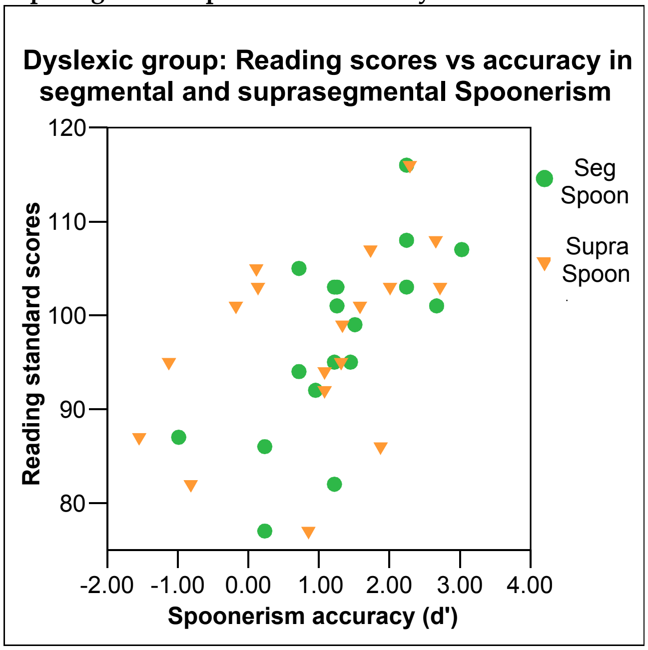
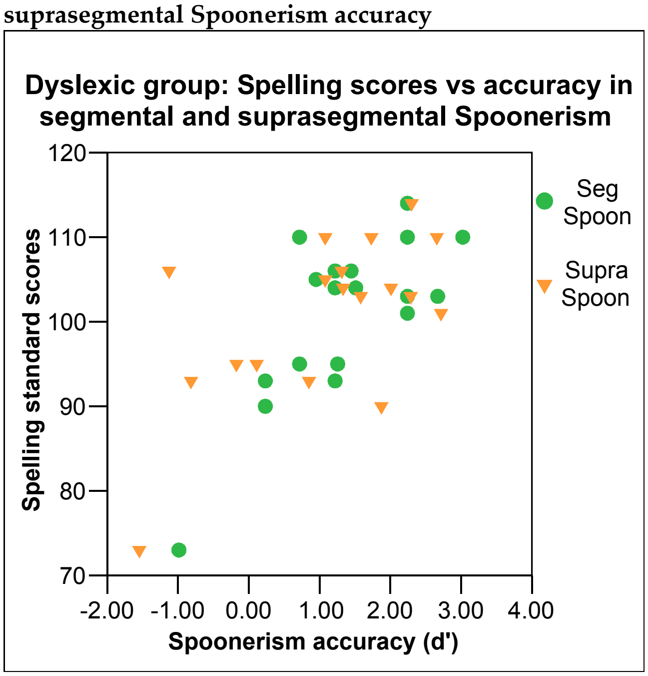


Figure 5.8 below shows the relation between the dyslexic group's accuracy on the segmental and suprasegmental versions of the Spoonerism task and their WRAT Spelling standard scores.

Figure 5.8. Dyslexic group's WRAT Spelling scores against segmental and suprasegmental Spoonerism accuracy



In general, higher Spoonerism accuracy is associated with higher Spelling scores. It can however be seen from the figure that one individual, with a particularly low Spelling score, also had low *d′* values in both the segmental and the suprasegmental versions of the Spoonerism task. When this individual's data was removed from the analysis, the correlation between the group's Spelling and segmental accuracy remained significant (r = .610, p = .007), but the correlation between Spelling and suprasegmental accuracy was no longer significant (r = .396, p = .116).

When the dyslexic group's WRAT scores were correlated with their response times for the Spoonerism task, none of the results were significant. The coefficients are shown in Table 5.10 below.

Table 5.10. Correlation of dyslexic group's WRAT Reading and Spelling standard scores with response times in the two manipulation tasks

	WRAT Reading	**WRAT Spelling**
Segmental Spoonerism (msec)	r = -.035 p = .886 n = 19	r = -.016 p = .947 n = 19
Suprasegmental Spoonerism (msec)	r = -.090 p = .722 n = 18	r = -.067 p = .791 n = 18

The dyslexic group's performance on the Spoonerism task in relation to their WRAT scores can therefore be summarised as showing a positive relationship between segmental accuracy and both the WRAT measures, with a relationship also appearing between suprasegmental accuracy and Reading.

5.7.2 Discussion of the relationship between the Spoonerism task and WRAT measures

The findings for the segmental version of the Spoonerism task were similar to previous studies. The link that was found between the dyslexic group's performance in Reading and their accuracy in the segmental Spoonerism task matches with the findings of Judge et al (2006), that word reading skills (as measured by WRAT Reading) were significantly correlated with accuracy in the group of university students with dyslexia investigated in their study. However, the relationship which was also found between WRAT Spelling and segmental Spoonerism accuracy in the present study was not found by Judge et al (2006). Additionally, although in the present study there was also a relationship between segmental Spoonerisms and Spelling for the control group, no relationship between spoonerisms and the WRAT measures was found for the control group in Judge et al's study (although Judge et al's control group did show a relationship between Reading and a composite measure of phonological processing which included spoonerisms, phoneme deletion latency, and rhyme fluency).

In general terms this finding of a relationship between literacy measures and segmental Spoonerism performance is also similar to what is reported by Ramus et al (2003). Ramus et al (2003) reported that a composite measure of phonology which included spoonerisms was an excellent predictor of a composite measure of literacy. However, in Ramus et al's (2003) study, the phonology measure included not only spoonerism accuracy (and response time) but also latencies for picture naming and digit naming, accuracy on a nonword repetition task, and a standardised index of working memory. These tasks are clearly somewhat diverse, drawing on not only phonological manipulation skills but also speed of processing and working memory, and so although it is plausible that the spoonerism task would have made a contribution towards the overall result, the outcomes of the 2003 study and the present study are not entirely directly comparable.

It was also shown that there was a relationship between the suprasegmental Spoonerism task and performance on the Reading task specifically. This relationship was significant for both groups, and it did not extend to Spelling scores for either group. This new finding has implications for the Phonological Deficit Hypothesis in a way that the Pig Latin task did not, in that to the extent that a correlation between segmental spoonerism performance and word reading is taken to be indicative of a relationship between phonological processing and literacy, for consistency, the correlation between reading scores and performance in the suprasegmental version of this task should also be seen as indicating that suprasegmental manipulation skills are highly relevant for literacy, since the two versions of the task are as equivalent as they can be given the differences between segmental and suprasegmental phonological phenomena generally. More particularly, if the Phonological Deficit Hypothesis receives support from the relationship between segmental spoonerism performance and Reading scores which has been reported by Ramus et al (2003) and Judge et al (2006), then the same kind of implications should be drawn from the relationship found here between suprasegmental spoonerism performance and Reading scores. Rather than supporting the narrow reading of the Phonological Deficit Hypothesis, this finding is suggestive of a need to incorporate suprasegmental skills as well as segmental skills into the account of the relation between phonological processing and reading.

5.8 Conclusions arising from the Spoonerism task

Segmental Spoonerism tasks have been used in a fairly large number of the studies which have investigated the phonological skills of adults with dyslexia, as they seem to be one of the tasks which successfully show differences between even 'high-functioning' or well compensated individuals with dyslexia and their non-dyslexic peers. The results of the segmental version of the Spoonerism task reported in the present chapter fit well with this consensus in the existing literature, and certainly more comfortably than the results of the segmental Pig Latin task reported in the Chapter 4, as they showed that the control group was able to perform the segmental version of this task with significantly greater accuracy than the dyslexic group, although both groups (rather than the dyslexic group only) found the segmental task more difficult when the words which had to be spoonerised had cluster onsets instead of singletons.

The question which this chapter particularly intended to address is whether these deficits in segmental tasks would also be found when the spoonerism modification involved the manipulation of suprasegmental units. As was shown in §5.5, differences between the groups were found in both the segmental and suprasegmental versions of this task, with the group of individuals with dyslexia performing with less accuracy than the group of non-dyslexic controls. It was also shown in this chapter (§5.7) that there was a relationship between accuracy levels in the Spoonerism task and performance in the WRAT measures, for both groups. The relationship with WRAT Reading (especially) extended not only to accuracy in the segmental version of the task but also the suprasegmental version, indicating that whatever skills are being measured by the suprasegmental Spoonerism task (whether they are different from, or in principle the same as, those being measured by the segmental version of the task), they have a relationship with the literacy skills of these individuals with dyslexia which has not up to now been recognised.

In relation to the argument presented in Chapter 1, it should again be noted that the main impact of these findings is to do with the cognitive demands involved in manipulation tasks themselves, more than the fact that the deficit shown for the dyslexic group involves suprasegmental aspects of phonology. That is to say, the argument in Chapter 1 does not invest particularly heavily in the results of this chapter (or the previous chapter), since it mainly has to do with the nature and role of metalinguistic manipulation skills in dyslexia (regardless of whether the manipulation is segmental or suprasegmental), in contrast to the Phonological Deficit Hypothesis, for which the question of which phonological domains may or may not be involved is more of a priority.

However, the findings of this chapter have a significant bearing on the Phonological Deficit Hypothesis, partly because they demonstrate that whatever role is played in dyslexia by impairments in the skills which underpin successful performance of segmental spoonerism tasks, either the same role or a closely analogous role is played by the skills which are involved in suprasegmental spoonerism performance. In addition to this, however, these findings pose a challenge for the Phonological Deficit Hypothesis, because the finding of a suprasegmental manipulation deficit (which mirrors so closely the well-known and heavily depended on segmental deficit in spoonerism tasks) is something which can only be incorporated into the theory under the 'broad' reading of its claims. Just as segmental manipulation deficits are interpreted within the framework of the Phonological Deficit Hypothesis as showing evidence of a deficit in segmental representations, a suprasegmental manipulation deficit should, analogously, be interpreted as evidence of a deficit in suprasegmental representations. This would, however, raise the further question of how impaired suprasegmental representations play a causal role in reading impairment: since the hypothesis itself consists of a claim that impaired phonological representations cause reading impairment, if the referent of 'phonological representations' is taken to include suprasegmental phonological representations, then the hypothesis becomes a claim that suprasegmental as well as segmental phonological representations are not only impaired, but impaired in such a way as to cause reading impairment. This is one challenge for the Phonological Deficit Hypothesis; but one additional challenge which the hypothesis as a whole would be confronted with is that it was not after all this 'broad' reading which was supported by the findings of the previous three chapters, but rather the 'narrow' reading, the reading which does not predict that any deficit will be apparent in suprasegmental manipulation skills. This issue will be explored in greater depth in the next chapter, Chapter 6, which will bring together the findings of all four of the tasks which have now been reported, with a view to examining their various implications for theories of dyslexia, and the Phonological Deficit Hypothesis in particular.

Chapter 6

General discussion

6.1 Introduction

The key questions which the experiments reported in the previous four chapters were designed to address were as follows. One aim was to test whether phonological representations in dyslexia still seem to be impaired once steps are taken to avoid the confound between orthography and phonological representations. This question was addressed in the 'Interpretation' task reported in Chapter 2, where minimal pairs were used to investigate the representation of both segmental and suprasegmental contrasts, and where no evidence was found that the dyslexic group was impaired in the suprasegmental contrasts relative to the control group (ceiling effects in the dyslexic group's accuracy on the segmental Interpretation task meant that no firm conclusions could be drawn about any possible differences between the groups in terms of their implicit knowledge of segmental contrasts). A second question was to establish whether basic metalinguistic skills, where participants are required to focus on the auditory form of words apart from meaning, were impaired in dyslexia, either for segmental or suprasegmental units. This was addressed in the 'Recognition' task in Chapter 3, where again the performance of the dyslexic group did not differ from that of the control group. In the two chapters which followed, the aim was to establish whether dyslexics' known deficit in manipulating segmental units would extend to suprasegmental units. In Chapter 4 this was investigated using a 'Pig Latin' task, where only one unit was manipulated at a time. Here the two groups differed in the segmental version of the task, with a deficit appearing in the dyslexic group, in line with previous findings, but there was no difference between the groups in the suprasegmental version. Finally, in Chapter 5, in the 'Spoonerism' task, where two units were required to be exchanged at a time, it was seen that the performance of the dyslexic group was weaker than that of the control group, in both the segmental and the suprasegmental versions of the task. Here it was seen that although the ability to manipulate segmental units is a skill which clearly differentiates between dyslexics and controls, there was a divergence in the two tasks in their suprasegmental versions: the groups did not differ in accuracy in the suprasegmental Pig Latin task, but the control group outperformed the dyslexic group in the suprasegmental Spoonerism task.

These findings can be presented in tabular form as follows. Table 6.1 on the following page shows the four tasks (and the skill which each putatively assessed), along with a summary of how the groups performed in each version of the task. The ceiling effects which were found in the segmental version of the Interpretation task are noted (no ceiling effects were found in the other tasks).

Table 6.1. Summary of results of the four experiments (§2-§5)

		Segmental version	**Suprasegmental version**
implicit	**Interpretation**	(no effect for Group; Dys at ceiling)	Dys = Con
basic metalinguistic	**Recognition**	Dys = Con	Dys = Con
manipulation 1	**Pig Latin**	acc: Dys < Con RT: Dys = Con	acc: Dys < Con RT: Dys = Con
manipulation 2	**Spoonerism**	acc: Dys < Con RT: Dys = Con	acc: Dys < Con RT: Dys = Con

Key to abbreviations: *"="indicates that the performance of the groups did not differ significantly from each other; "m < n" indicates that group m was outperformed by group n.*

As was discussed in the individual chapters in connection with each individual experiment, the tasks were administered with a view to testing the predictions of the three alternative accounts (namely, the 'narrow' reading of the Phonological Deficit Hypothesis, the 'broad' reading of the Phonological Deficit Hypothesis, and the Metalinguistic Hypothesis). Table 6.2 shows the predictions which were made for the performance of the dyslexic group relative to the control group, for each of the three alternatives presented in Chapter 1.

(Table 6.2 is shown on the following page.)

Table 6.2. Summary of predictions made by the three alternative hypotheses

	Predictions of the 'Narrow' Phonological Deficit Hypothesis		**Predictions of the 'Broad' Phonological Deficit Hypothesis**		**Predictions arising from the Metalinguistic Hypothesis of Chapter 1**	
	Seg	**Supra**	**Seg**	**Supra**	**Seg**	**Supra**
Interp (§2)	dys impaired	dys unimpaired	dys impaired	dys impaired	dys unimpaired	dys unimpaired
Recog (§3)	dys impaired	dys unimpaired	dys impaired	dys impaired	dys impaired	dys impaired
Pig Lat (§4) & Spoon (§5)	dys impaired	dys unimpaired	dys impaired	dys impaired	dys impaired	dys impaired

Table 6.3 shows in summary form whether the predictions made by each alternative account were borne out by the results of the various tasks in their segmental and suprasegmental versions.

(Table 6.3 is shown on the following page.)

Table 6.3. Summary of how the results supported the predictions of each account

	Predictions of the 'Narrow' Phonological Deficit Hypothesis		Predictions of the 'Broad' Phonological Deficit Hypothesis		Predictions of the Metalinguistic Hypothesis of Chapter 1	
	Seg	**Supra**	**Seg**	**Supra**	**Seg**	**Supra**
Interpretation	(dys at ceiling)	supported	(dys at ceiling)	not supported	(dys at ceiling)	supported
Recognition	not supported	supported	not supported	not supported	not supported	not supported
Pig Latin	supported	not supported	supported	supported	supported	supported
Spoonerism	supported	not supported	supported	supported	supported	supported

This chapter is devoted to providing a more in-depth discussion of the various implications which follow from these findings. In what follows, I will break down the discussion into two general points which either arise directly from the experimental results or need to be addressed as having a bearing on the interpretation of these results. Firstly, §6.2 will be devoted to exploring the question, *To what extent can phonological representations be said to be impaired in dyslexia?* In this section I will show the extent to which the various different hypotheses which were articulated in §1.5 were supported by the findings which were reported in Chapters 2 to 5. The Phonological Deficit Hypothesis will be examined in order to ascertain whether the 'narrow' reading is substantiated by the results more than the 'broad' reading, given that both versions (by definition) make the claim that some representations are impaired, and both of these renditions of the Phonological Deficit Hypothesis will be contrasted with the Metalinguistic Hypothesis of Chapter 1 (summarised in §1.5), which makes no claim that representations are impaired.

Then secondly, the discussion will focus on the question, *If phonological representations are not impaired, what then is the role of phonology in dyslexia?* Here I will suggest that if there is a phonological component to the cognitive deficits which are manifested by individuals with dyslexia, it should be conceptualised as a strictly metaphonological deficit: if a phonology-related deficit plays a role in the manifestation of dyslexia (or has some causal connection with it), this deficit should be identified as some variant or aspect of metalinguistic proficiency. I will argue ultimately (§6.4) that since manipulation of phonological units is not something necessary for the successful comprehension or production of spoken language, and nor does it contribute to the implicit categorisation of speech sounds into meaning-relevant categories, the role for phonology in causal theories of dyslexia may have to be regarded as somewhat limited.

6.2 What is the nature of phonological representations in dyslexia?

In this section, the discussion will focus on each of the various hypotheses which were tested in the different experiments – the narrow reading of the Phonological Deficit Hypothesis, the broader reading of the Phonological Deficit Hypothesis, and the hypothesis arising from the Metalinguistic Hypothesis presented in Chapter 1. It will be argued that although none of these hypotheses receives unqualified support from the experimental results, there are grounds to reject the view that phonological representations (as such) are impaired in dyslexia – indeed that any explanation which views phonological representations as having any major causal role in dyslexia cannot be entirely adequate.

6.2.1 Outcomes for the 'narrow' reading of the Phonological Deficit Hypothesis

The Phonological Deficit Hypothesis in its accepted form states that "phonological representations" are impaired in dyslexia (and are the source of the reading difficulties seen in dyslexia). Chapter 1 explained how two alternative renditions of this statement can be set out, to distinguish between what 'phonological representations' invoked in this unqualified manner could refer to. Here we examine more particularly the 'narrow' reading of the hypothesis – where "phonological representations" are interpreted as referring implicitly to segmental representations, to the exclusion of suprasegmental representations.

What the narrow reading of the hypothesis predicted was that a deficit should be seen in the segmental version of all four of the tasks in the present study, and that no deficit should be seen in the suprasegmental version of any of these four tasks. The segmental aspect of this claim was by and large borne out in the results, especially in the results of the segmental Pig Latin and segmental Spoonerism tasks, which mirror the results of existing studies. The ceiling effects in the segmental Interpretation task were disappointing for this hypothesis, as they were for all three hypotheses, but it would be in keeping with how the Phonological Deficit Hypothesis interprets the results of other segmental manipulation tasks to say, for example, that the segmental deficit in the Pig Latin and Spoonerism manipulation tasks is indicative of a segmental deficit in representations (that is, such a way of interpreting the results would be congruous with how existing findings have previously been interpreted from the perspective of the Phonological Deficit Hypothesis.) This putative deficit, it could then be argued, happened not to manifest itself in the segmental Interpretation task in the present study because the task was too easy or because it is a deficit which exists in childhood and may have resolved in adulthood or been compensated for by this group of participants. A similar line of argument could also be taken with the lack of a group effect in the Recognition task. Further, the narrow reading of the Phonological Deficit Hypothesis receives some support from the results of the suprasegmental Interpretation task, where, as predicted, no suprasegmental representational deficit is found. Up to this point therefore the narrow reading of the Phonological Deficit Hypothesis is borne out.

Before pointing out some ways in which the results of the current study are unfavourable for this reading of the Phonological Deficit Hypothesis, it will be of value to explore some of the ways in which this support for the narrow reading of the hypothesis could be built on and extended. If the narrow version of the Phonological Deficit Hypothesis was accepted as being borne out by the present study, it would be possible to argue that the phonological deficit in dyslexia may well be restricted or limited to the segmental domain of phonology, with the suprasegmental domain left intact. In such an account, dyslexia might conceivably be considered as an example of a selective impairment of segment-level phonology, for example. This would make it similar to other selective impairments which have been identified in cognition, such as prosopagnosia and dyscalculia (Frith 1998). Additionally, in the light of reports that language impairment can manifest itself as a selective impairment of prosody (as detailed in the case study by Harris et al (1999) reviewed in Chapter 1), an account in which dyslexia was considered as a selective impairment of segment-level phonology could go on to make a case that there is a double dissociation between these two phonological domains. In spite of some serious reservations about the logical validity of double dissociations (articulated persuasively by, for instance, van Orden, Pennington, and Stone (2001) and Uttal (2003)), it is often standard practice to take double dissociations as evidence for modularity (see for example Appelbaum (1998)). This would then feed back into a model such as that proposed by Frith and Frith (1998) which postulates a modular cognitive architecture and locates studies of dyslexia within that framework. It is also a view which would fit well with the position presented in Stanovich (1988) and Snowling (2000).

Having said this though, there is evidence from the present study which throws doubt on the narrow reading of the Phonological Deficit Hypothesis, namely, the results of the Pig Latin and Spoonerism tasks. This is because the narrow reading of the Phonological Deficit Hypothesis predicts that since there is no suprasegmental representational deficit, there should be no suprasegmental manipulation deficit, but in fact the group of individuals with dyslexia were shown to have a deficit in the suprasegmental version of the two manipulation tasks. It would also be disadvantageous to the narrow reading of the Phonological Deficit Hypothesis if the suprasegmental Pig Latin and Spoonerism results are given the same interpretative treatment as the segmental manipulation results. If the reasoning which is applied to segmental manipulation tasks is applied to these suprasegmental manipulation tasks, then it should be concluded that a suprasegmental manipulation deficit is evidence of a suprasegmental representations deficit. However, such a conclusion would conflict with the evidence which was provided by the suprasegmental version of the Interpretation task, which gave no grounds for saying that suprasegmental representations are impaired in this group of individuals with dyslexia.[1]

This shows that although there is some support for the narrow reading of the Phonological Deficit Hypothesis in the present results, this hypothesis is not fully robust or able to account for all the findings. We turn now to examine the broad reading of the Phonological Deficit Hypothesis in the following subsection.

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[1] It could of course be argued that the suprasegmental version of the Pig Latin and Spoonerism tasks was too difficult, or too non-phonological, to provide strong evidence in this context. But such a claim would need to be equally applied to the segmental version of these tasks, given that the two versions of the tasks were as closely matched as possible, and excluding the data from segmental manipulation tasks on such grounds would not be desirable for the Phonological Deficit Hypothesis, since the segmental version of these tasks seems to be so well established as a test of 'phonological processing'. It should also be noted that in fact there was no domain effect in the Spoonerism task – the segmental and suprasegmental versions were found to be equally difficult for both groups.

6.2.2 *Outcomes for the 'broad' reading of the Phonological Deficit Hypothesis*

The 'broad' reading of the Phonological Deficit Hypothesis is the one where the 'phonological representations' which are included in the formulation of the hypothesis are interpreted as implicating both segmental and suprasegmental representations. The present section summarises and discusses, relatively briefly, the support which can be derived from the findings of the four experiments for this version of the hypothesis.

The broad reading of the Phonological Deficit Hypothesis predicted that deficits would be seen in both the segmental and the suprasegmental versions of all the tasks in the present study, whether they tested representations or manipulation skills. There is in fact less support for this reading of the hypothesis than for the narrow reading (although they both coincide in predicting the deficits which were found in the segmental manipulation tasks). The main finding which was clearly consistent with the predictions of the 'broad' reading of the hypothesis was that the performance of the dyslexic group was weaker than that of the control group in both versions of the Pig Latin and Spoonerism tasks, which constitutes evidence that suprasegmental manipulation skills are impaired, a consequence which the Phonological Deficit Hypothesis assumes to follow from an underlying representational deficit.

However, it must be pointed out that neither of the other tasks afforded any support for the broad reading of the hypothesis. In the Recognition task, the lack of evidence for a segmental deficit is troublesome for all the competing hypotheses, but the prediction of the 'broad' hypothesis in relation to the suprasegmental version was not supported. Most telling of all were the results of the Interpretation task, which tested the nature of the dyslexic group's suprasegmental representations as directly as possible. In this task the dyslexic group's performance was equivalent to that of the control group's, suggesting that their suprasegmental representations are not impaired (and not the source of the observed deficit in suprasegmental manipulation), and making the broader reading of the hypothesis essentially unsustainable.

6.2.3 Outcomes for the Metalinguistic Hypothesis of Chapter 1

It is worth recalling at this point that whereas the discussion of the Phonological Deficit Hypothesis revolves around the difference between segmental and suprasegmental areas of phonology, this difference is much less significant from the perspective of what was argued in Chapter 1 (summarised in §1.5). From this perspective, the suprasegmental versions of the tasks were included simply because they provided a means of testing areas of phonology which were non-overlapping with orthography – an important difference, but one which is assumed to be incidental rather than reflective of a qualitative difference between the two areas of phonology. It is therefore more the difference between implicit and metalinguistic knowledge which gives rise to the different predictions of this proposal, rather than the distinction between segmental and suprasegmental phonology as such.

The central prediction of this hypothesis was that in the task which tested implicit representations, no deficit would be seen when these representations were independent of orthography. In the Interpretation task, because metalinguistic demands were excluded, participants had to rely on implicit knowledge of how the sounds of the words or word sequences they heard should be interpreted. Although in the segmental version it was in principle impossible to distinguish this knowledge from orthographic information about the words in question, in the suprasegmental version, it was possible to ascertain how successfully participants could draw on their implicit knowledge of how the different stress patterns differentiated meaning. The prediction that no deficit would be seen in the orthography-independent version was indeed borne out. Additionally, the prediction that any aspect of spoken language at all would be difficult for individuals with dyslexia to analyse metalinguistically was borne out in the results of the Pig Latin and Spoonerism tasks, where the ability to exchange both segmental and suprasegmental units was shown to be impaired in the dyslexic group.

However, this prediction relating to metalinguistic analysis was not borne out in the results of the Recognition task. Speculations were offered in Chapter 3 as to why no group effects were found in the Recognition task – perhaps it was too easy, or insufficiently metalinguistic – and as noted previously, the lack of a group difference in this task deprives all three of the competing hypotheses of support.

6.2.4 Are phonological representations in dyslexia intact?

From this review of the three alternative hypotheses in the light of the findings of the present study, it can be seen that the two hypotheses which have the most support from the results of the study are the narrow reading of the Phonological Deficit Hypothesis and the Metalinguistic Hypothesis derived from Chapter 1. Neither of these hypotheses receives unqualified support from the evidence available, and so, up to a point, the decision to favour one rather than the other is driven more or less by theoretical and conceptual considerations.

The biggest conceptual problem for the Phonological Deficit Hypothesis, especially in its narrow reading, remains the tautology which has been identified in various places in the literature and was discussed in Chapter 1 (§1.3.2.2). That is, the onus remains on this hypothesis to distinguish between what is an orthographic problem and what is a segmental phonological problem, given the closeness of the association between orthographic experience and the shaping of segmental phonological representations, while at the same time such a distinction remains impossible to make. Instead, as I have been arguing, it is necessary to recognise that claims made for segmental phonology are thoroughly compromised when they do not take account of the influence of alphabeticism, and that in the context of literacy impairments it is of fundamental importance to ensure that the kind of 'phonology' under investigation is distinguishable both conceptually and in practice from literacy experience. It is because segments are related to written text that this area of phonology should be expected to appear to be impaired in dyslexia, and if individuals with dyslexia are shown to be impaired specifically in the representations (not metalinguistic analysis) of segments, the only way to step out of the conundrum posed by their dual identity as putatively phonological and clearly orthographic units is either to acknowledge that claiming a phonological impairment in segments in individuals with literacy impairment is tautological, or to say that the apparent impairment of segmental phonological representations in dyslexia is an artefact of the socio-cultural/historical fact that phonological segments are associated with a written notation, and so not an impairment of phonology in the sense of spoken-language-specific knowledge at all. This position is well buttressed by the results of the suprasegmental Interpretation task, in that it bears out the view that when implicit phonological knowledge is isolated from the input from orthography, there is neither theoretical reason nor suggestive evidence in favour of a deficit in dyslexia.

What I would like to suggest therefore is that the lack of a suprasegmental representational deficit casts doubt on the view that there is a deficit in phonological representations in general (a claim which would include segmental phonological representations if there is any sense in which such representations can be conceived of as non-orthographic).

What I specifically mean by intact representations is along these lines. Assuming that speakers have implicit knowledge of the sounds of language (which may or may not be organised in ways amenable to analysis in terms of formalisms), and assuming that this knowledge of the sounds of language is what enables comprehension and allows production (although it may or may not be related to comprehension and production through the mediation of mental symbols), and assuming that what makes this knowledge phonological is primarily that it respects spoken rather than written language, then this knowledge is intact in dyslexia.

Two important caveats need to be inserted at this juncture, however. The first of these relates to the question of the exact relationship between segments and suprasegmentals, since the position I am arguing for depends on understanding segmental and suprasegmental areas of phonology as being fundamentally the same, rather than qualitatively different. The second is the extent to which genuinely phonological aspects of implicit knowledge have been tested in the suprasegmental Interpretation task (which provides the key experimental evidence in support of my position). I will discuss these two points in turn here, before returning to the general claim that phonological representations are the wrong place to look in the search for an impairment which characterises dyslexia.

On the first question, of the relationship which holds between segmental and suprasegmental areas of phonology, it is a key feature of my position that the only difference between segmental and suprasegmental minimal pairs is in the availability of orthographic notation for the former but not the latter. In other words, the fact that the stimuli can be differently classified according to their place in the phonological hierarchy is merely incidental – the only relevant distinguishing feature which was recognised in the rationale for this study is that some of them have written counterparts (the ones which happen to be segmental) and others, namely the ones which happen to be suprasegmental, have no written counterpart in conventional written English. While this difference is of course critically important for the experimental design, my position is that it does not reflect or parallel any more fundamental or qualitative difference between the two kinds of stimuli in terms of their phonological status.

This suggested treatment of segmental and suprasegmental phenomena is not beyond dispute, however. In fact, the very opposite position is more common in the literature – namely, the view that suprasegmental phenomena are qualitatively different from segmental phenomena, and perhaps even constitute a separate domain altogether within phonology. It is in fact a longstanding and uncontroversial view in the literature that prosodic/suprasegmental phenomena are qualitatively different from segmental phenomena; as has been stated, "there is a difference in kind between segmental features proper and the features of pitch, stress, and quantity" (Lehiste 1970: 2); see also Fox (2000: §1), McMahon (2007).

The main reason for dissatisfaction with the 'two-domains' argument is the grounds which exist for believing that the qualitative distinction between segmental and suprasegmental features may be fairly artificial. Many of the arguments presented in Chapter 1 in support of the Metalinguistic Hypothesis (§1.3.2, for instance), imply that the perceived difference is more of an accidental byproduct of the historical tradition of notating speech using segmented alphabetic symbols, which are unsuitable for representing prosodic features of the speech stream, and so make prosodic features seem harder to notate and analyse. In reality, of course, even the parts of the speech stream which are typically notated by segmental alphabetic symbols share many of the properties of those parts which are conventionally identified as prosodic – in extending beyond the single segment in particular (see, for instance, the discussion of vowel nasalization by Silverman (2006), which highlights the artificiality of treating the nasalization that inevitably precedes a nasal consonant as having,

> "a different phonological status than the nasal consonant, which is the 'true' underlying phonological value … despite the fact that the vowel nasalization

> co-varies with the other cues to the oral component of the nasal consonant … [and] is functionally non-distinct from the nasal consonant itself" (Silverman 2006: 209)).

It is important therefore to take seriously the observation that the speech stream is a single event, whether considered acoustically, perceptually, or articulatorily: because of its continuous nature, and the fact that the elements which it can be broken down into both overlap in space and simultaneously co-occur, the more that we learn about its acoustic and articulatory properties, the less adequate any account that gives a particularly prominent theoretical place to segmental features *as features of segments* begins to appear, and it is quite possible that treating more of the properties of the speech stream as prosodic rather than segmental would give rise to a more realistic description and analysis than does treating it as consisting of two fundamentally different kinds of element as in the 'two-domains' approach.

A couple of further more detailed points can also be raised against the view that segmental and suprasegmental areas of phonology are two qualitatively different domains. One is that there does not seem to be any satisfactory phonetic basis for distinguishing segmental from suprasegmental features. Fox (2000) does suggest that suprasegmental features differ from segmental features in that they are not produced in the oral cavity (i.e. they are not supralaryngeal). According to this position,

> "most of the segmental features of speech are produced by the supralaryngeal component," and,

> "place and manner of articulation depend on the postures and movements of the tongue, velum, jaw, and so on" (Fox 2000: 3).

However, as recognised by Fox (2000: §1.2) there are several difficulties with this suggestion. It does not provide any positive means of distinguishing prosodic from segmental features, for instance – the definition of suprasegmentals is based on exclusionary criteria (being not produced supralaryngeally) – and in fact necessarily so, since while it may be the case that no prosodic features are produced in the oral cavity, still, some features which are not produced in the oral cavity are nevertheless regarded as unambiguously segmental rather than prosodic (such as voicing, which is generally taken to be a segmental feature, but which originates phonetically (acoustically, physiologically) in the larynx). More significantly, from a phonetic point of view, the motivation for identifying segmental features as distinct from suprasegmental features in the first place is not explained. Acoustically it is the same phenomena which underlie the identification of both segmental and suprasegmental features, and the articulatory criteria discussed by Fox are more in the nature of post hoc justifications for prior decisions than of diagnostics for differentiating a particular phenomenon as either segmental or suprasegmental. They are not really a solution to the problem of identifying segmental features unless segments are taken as a given in advance. There should be a way of defining segments first, i.e., independently of articulation – but since no such definition is provided, and the motivation for positing segments is left unspecified, the investigation of what articulatory properties unite the features we identify as segmental must be done entirely post hoc, with the division already in place. The question which therefore arises with some urgency is whether or not this division between segmental and prosodic features should simply be acknowledged to be more or less arbitrary. A comment made by Abercrombie (1991) as part of a bigger discussion of segmentation would in fact seem to be indicating that the division is indeed arbitrary:

> "It should be noted, incidentally, that it is not the flow of speech in its entirety that is segmented. Voice quality, pitch variation, loudness variation, rhythmic characteristics, for example, are set aside first. Segmentation then takes place of what is left. Martin Joos describes the phonetic analysis of speech as having two dimensions: splitting speech into simultaneous components; and cutting speech into consecutive pieces. Both operations are involved in establishing segments. The first operation is applied only up to a certain point; the second is applied to what is left. The latter gives us the segments and the former gives us the suprasegmental features." (Abercrombie 1991: 28)

That is, unless the "certain point" at which the consecutive pieces can be segmented is specified, and unless the motivation for "setting aside" some of the components can be established, these twin operations cannot be said to have a principled basis,[2] and in the absence of a rationale for distinguishing segmental from suprasegmental features in the first place, the possibility that they constitute qualitatively different phonological domains is clearly fundamentally undermined.

Nor does there seem to be a strong linguistic or phonological argument in favour of a qualitative distinction between the segmental and suprasegmental domains. It has been argued that a basis for making such a distinction comes from the fact that segments are paradigmatic units whereas suprasegmentals are syntagmatic.[3] However, if the only criterion for identifying something as syntagmatic is that it extends beyond the segment, then almost all the properties identified as segmental would actually be syntagmatic. Voicing, palatality, labiality, aspiration, glottalisation, and so on, all extend beyond the segment. Although this is recognised by Fox and indeed built into the formalism of autosegmental phonology, it does not prevent segments from being called paradigmatic rather than syntagmatic, again reinforcing the point that external considerations must have been in place in order

[2] Indeed Fox (2000: 3) accepts that prosodic features "appear to form a very disparate group" when seen in terms of their acoustic and articulatory properties – and these are the features which Abercrombie says are "set aside first" when speech is segmented in analysis. Thus we are left with a disparate group of phenomena, classed together on the basis that they are *not segments*, but still in the absence of a definition of a segment itself, which is not a very satisfying state of affairs.

[3] It has also been claimed in the literature that suprasegmentals are distinguished from segments by being *both* syntagmatic *and* paradigmatic (Fox (2000). But this claim seems to embody some confusion. Whereas paradigms are lists of interchangeable options, syntagms are collocations; they are as different as the vertical and horizontal axes on a graph, for example, and there does not seem to be a way in which any particular linguistic phenomenon could coherently be described as both syntagmatic and paradigmatic simultaneously. The specific example which is used in support of the 'both-and' claim for prosody is time, or duration (Fox 2000): duration is said to be both a segmental property (in which case it is called 'length' in phonology) and also a suprasegmental property (in which case it is called 'weight' or 'quantity'). But this example does not provide evidence that *prosodic features* can be both syntagmatic and paradigmatic – what it shows is that *some acoustic property* of the speech stream can be put to use in a language in either or both of these ways. That a single acoustic property of the speech stream can be multi-purpose in a language system is of course not a particularly controversial claim, but it is not a claim which contributes to the argument for or against a qualitative distinction between segmental and suprasegmental features.

to override the data which points to a syntagmatic (theoretically non-segmental) treatment of these phenomena. It should also be noted that the only prerequisite for establishing a paradigm is some unit or other, regardless of what size or shape the unit might be. Syllables and feet function equally well as units in a paradigm, for example, in cases where analytical or descriptive adequacy calls for these units rather than segments to be the terms in the paradigm. This point is also made by Lodge (2007):

> "At the heart of all linguistic theorising are the notions of paradigmatic and syntagmatic relations in language. But there is nothing that tells us a priori that paradigmatic relations that establish the meaningful contrasts of a language have to be between segment-sized entities at the phonological level any more than at any other level. In syntax, for example, a 'segment' is usually word-length, and certainly morpheme-length; the 'segment' is the smallest bit of the speech chain suitable for describing the patterns of a particular level. We segment speech in different ways for different purposes. Such segments include syllable places: onset, rhyme, nucleus and coda, the foot, the intonation group, the morpheme, and so on" (Lodge 2007: 80; see also Lodge 1997).

Paradigmatic status can therefore only be bestowed, so to speak, on units which have already been identified through prior analysis. Lodge's argument does not mean that 'phoneme'-like segments are intrinsically or by a priori necessity invalid as the units of some paradigm, but what it does mean is that the notion of a phonological segment must be motivated before it can stand in good stead in an analysis. Thus, while segments may well be descriptively useful, for non-literacy-impaired populations, or rather useful as transcriptional or other shorthands for phonological descriptions, their convenience in this respect is an insufficient reason for designing phonological analyses around them, or for subsequently calling them qualitatively different from suprasegmental phenomena.

Yet although arguments such as these tend to reinforce the position that the distinction between segmentals and suprasegmentals is more artificial than real, they do not in and of themselves rule out the possibility that a division between them might be characteristic of impaired phonological systems. It is after all possible that impairments of phonology may involve the phonological system being organised in a way which is not theoretically expected on the basis of how phonology is understood in the rest of the population, and this would be one route which could be followed by proponents of the narrow reading of the Phonological Deficit Hypothesis in support of the hypothesis that only the segmental domain is impaired in dyslexia. In theoretical phonological models such as Optimality Theory, for instance, it is recognised that certain constraint rankings in a grammar can sometimes give rise to unexpected outputs, which are termed 'pathological' (e.g. McCarthy & Prince 1995, Nelson 1998). Similarly, in clinical linguistics, one of the characteristics of phonologically disordered children is that their speech can contain 'idiosyncratic' features which are not usually attested in typically developing children (Stoel-Gammon and Dunn 1985). For instance, although cluster reduction is common in typical development, children with phonological disorder may reduce clusters by deleting the consonant that is normally retained (such as producing [ren] rather than [ten] for *train*). Other idiosyncrasies may include deleting singleton consonants in word-initial position (eg [ep] for *tape*), or substituting a preferred consonant for several other consonants in various locations (eg substituting [f] for most initial fricatives and affricates and also for initial stops in /stop + r/ clusters) (Stoel-Gammon and Dunn 1985; see also Grunwell 1987). The terminology of both theoretical claims and clinical descriptions could therefore, perhaps, be taken as indicating that there is no guarantee that ruling something out as an analysis of unimpaired phonological systems makes it impossible as an analysis of impaired phonology.

It would, however, be premature and superficial to conclude the discussion at this point, as this terminology does need further exegesis. For instance, in clinical linguistics in general, the great majority of productions of atypically developing children can be seen as systematic in their own terms, and they are often understood to be basically comparable with what is produced by younger, typically developing children. Not only so, but describing a child's productions as idiosyncratic does not imply that they are not amenable to analysis using the same tools as are available for analysing the productions of typically developing children: Gibbon (2007) illustrates phonological disorder with a case study of a boy whose productions are described as "idiosyncratic but nevertheless rule-based … his speech error patterns can be described succinctly in terms of phonological processes" (2007: 248). Similarly, in optimality theoretic phonology, the terminology of 'pathology' is not necessarily intended to refer to language impairment at all. Rather, the term is typically used to refer to outputs of the grammar which are less than ideal, for example by being unattested in the language under investigation, or conflicting with general principles of language. So whereas pathology in the grammar is to be avoided, such pathological forms are not treated in the literature either as descriptions of phonological impairment or as a prediction of the form that a phonological impairment might take. Indeed the very practice of seeking to apply theoretical models such as Optimality Theory to clinical data, as is done by Bernhardt and Stemberger (1998) and Dinnsen and Barlow (1998), among others, seems to presuppose that the principles which underlie these theories are not violated in any significant way by data from impaired speakers.

What this shows, therefore, is that when arguments are brought to bear on the question of whether segmental and suprasegmental areas of phonology constitute entirely separate domains, and when the discussion makes the division of phonology into these two domains implausible on principle as an analysis of unimpaired phonology, they simultaneously make it implausible as an analysis of phonological impairment. Although this implausibility may not rule it out entirely, in the present discussion, when it is taken in the broader context – of the paucity of evidence with a direct relation to non-metalinguistic knowledge in dyslexia, and of the results of Chapter 2 which showed the dyslexic group performing equally successfully with the control group – it contributes to a picture where a segment-specific deficit is less preferable than an interpretation of the results in terms of a more fundamental unity between segmental and suprasegmental areas of phonology.

On the second caveat mentioned above, a slightly briefer discussion is in order, since much of the background was already discussed in §1.4.2. The question here is whether the stress-based minimal pairs which were used in the Interpretation task reflect strictly phonological information, given that my argument assumes that there is a close if not identical relationship between the segmental and suprasegmental version of the task. Whereas the contrast involved in all the segmental minimal pairs in this task was lexical (this is part of what is included in calling such pairs conventional), the members of the suprasegmental minimal pairs which were used here consist of, on the one hand, a compound, which is a morphological unit, and a phrase, which is a syntactic unit. This means that, arguably, the suprasegmental Interpretation task could be construed as being more informative about participants' morphological and syntactic skills than their phonology. This kind of concern is one of the reasons which motivated the discussion in Giegerich (1992) as to whether pairs such as *black bird* can appropriately be called *minimal* pairs.

However, pairs such as 'toy factory' were identified in §1.4 as suitable for use in the present context because it is knowledge of the stress pattern which speakers and hearers must rely on in order to ascertain which is the appropriate meaning to be assigned to the auditory material, i.e., whether the structure is morphological or syntactic. Clearly, given that stress is clearly not truly phonemic in English, identifying genuinely identical segment-based and stress-based minimal pairs or tasks is a theoretical impossibility. Instead, the 'toy factory'-type phenomenon is as close as English allows us to come to investigating suprasegmental 'contrasts'.[4] It

[4] More accurately, this was felt to be the phenomenon which could most straightforwardly be incorporated into an appropriate experimental task in the present circumstances. There are other alternatives which fit Scobbie and Stuart-Smith's (2006) definition of quasi-phonemic contrast; these include their own example of so-called Scottish Vowel Length pairs (where in Scottish English vowels in morphologically complex words such as *brewed* and *tied*

can also be considered that even if the segmental minimal pairs in the present task had included morphologically complex words (e.g. *laughed/last*, *ploughed/cloud*, *bitten/mitten*, etc) it is not clear that the group of individuals with dyslexia would have shown a deficit in assigning the appropriate meaning to the word that they heard, or that if they had, that its relation to morphology rather than phonology would be any easier to disentangle (although of course it would be valuable to test this experimentally). Finally, and without going into an extended discussion on this point, it is perhaps worth simply mentioning that the force or significance of this characteristic of the suprasegmental minimal pairs varies depending on whether a monosystemic or a polysystemic view of language is adopted. If it is assumed that the phonology of a language is one single system which should be analysed independently of the rest of the language and its grammar, then the fact that non-phonological information is involved in the suprasegmental minimal pairs is clearly a problem which makes the relationship between these minimal pairs and conventional segmental minimal pairs a great deal more distant. It is much less of a problem if it is assumed that phonological systems can interact with other systems in the language, and that a phenomenon which is observed only in a restricted range of instances (defined or identified perhaps on non-phonological grounds) can still be regarded as phonological (Scobbie & Stuart-Smith 2006). This, however, is perhaps more marginal a controversy than the present context requires.

In summary, what the foregoing discussion shows is that after taking these caveats into account, the general principle that implicit spoken-language-specific knowledge is intact in dyslexia remains available as a viable interpretation of the results of the present study.

To return, then, to the claim itself, it implies, crucially, that the role of phonological representations in general in dyslexia needs to be downplayed in any causal

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are consistently longer than their monomorphemic counterparts *brood* and *tide*), and noun/verb stress pairs such as ˈ*import* versus *im*ˈ*port*.

hypothesis. The deficits which are (regularly, robustly, indisputably) found in dyslexia in tasks involving phonological segments must have an explanation somewhere other than in phonological representations. I will discuss below (§6.3) what I think the details of this explanation could be, but for now it is enough to make the claim that this argument provides a basis and an incentive for thinking about dyslexia with much less emphasis on phonological representations. Although the debates in the current literature surrounding the causes of dyslexia are based squarely on invocations of phonological representations, the present results, interpreted from the perspective of my stance on the relation between segments and orthography and prosody, show that this is unlikely to be adequate: the role of phonology in dyslexia may actually be rather more limited than is currently acknowledged.

Further and substantial support for this position can be adduced from a recent article by Ramus and Szenkovits (2008), which independently reached a remarkably similar conclusion. Parts of the material in this paper, titled 'What phonological deficit?' were covered in Chapter 1 (§1.3.3), where the evidence for and against a strictly representation-level deficit was discussed. As a brief recapitulation, it may be recalled that Ramus and Szenkovits reviewed several studies, including ones which investigated what they call 'phonological grammar,' the probabilistic and typically language-specific processes which can be found in speech production and perception, such as voicing assimilation in French and perceptual illusions induced by phonotactic constraints. In comparisons of dyslexic and non-dyslexic university students on these aspects of phonological grammar, the students with dyslexia did not show the performance which would be expected if their phonological representations were impaired. For example, in French, voicing spreads backwards from obstruents and fricatives to the preceding consonant (e.g., the voiceless plosive in *cape* is realised as voiced in a phrase such as *cape grise* [kabgriz], but not before a nasal (*cape noire* [kapnwar]). In one of the experiments reviewed by Ramus and Szenkovits, participants were played a target word such as *cape* and had to state whether it was included in the sentence which followed. In sentences which contained the target word, it was presented either assimilated in the appropriate context ([kabgriz]) or assimilated in an illegal context (*[kabnwar]). If phonological representations were impaired in dyslexia, it might be expected that individuals with dyslexia would be relatively insensitive either to the assimilation or to the legality of the assimilation context, but the results showed that the dyslexic group and the control group were responding in the same way. Another study exploited the fact that when listeners are presented with clusters which are illegal in their language (such as word-initial [tl] or [dl] in French), they often assume that the sequence was its closest legal counterpart ([kl] or [gl]), and they also report [dla]-[gla] pairs as being the same rather than different in discrimination tasks. When individuals with dyslexia were tested in this type of speech perception task, it was found that they were just as liable to the perceptual illusion as non-dyslexics, indicating that speech perception in dyslexia is just as much constrained by native language phonotactics as it is in individuals with no history of dyslexia. As the authors put it in summary,

> "the aspects of phonological grammar that we have investigated seem perfectly normal in people with dyslexia … Our results are consistent with the hypothesis that phonological representations are intact, that grammatical processes that operate on them are intact too, and that the deficit lies somewhere else" (Ramus & Szenkovits 2008: 135).

They draw the same conclusion from subliminal priming tasks – whereas dyslexics would be expected to show reduced subliminal priming effects if their phonological representations are 'degraded,' it was found instead that dyslexics showed as much subliminal priming as controls (and were affected in the same ways):

> "These results do not support the predictions of the degraded phonological representations hypothesis … Rather, they are compatible with the idea that their phonological representations and processes for lexical access are intact" (Ramus & Szenkovits 2008: 136).

The corroboration provided by this article is particularly valuable to the arguments being presented here, as the approach adopted in it is quite different from the one taken in this thesis. What the authors have done is to take the Phonological Deficit Hypothesis in good faith and attempt to find direct evidence of the impairment of phonological representations which they initially believed existed. To the extent that abstract cognitive structures and processes can be examined 'directly,' the methods used in the studies reviewed there are impeccable, and very wide-ranging, implementing in sometimes innovative ways a variety of the aspects of what theoretical phonologists would recognise as phonology-proper. What the authors go on to suggest for how the phonological deficit should be understood, if not in terms of phonological representations as such, will be discussed in the next section; for the time being, the key point is that their article constitutes an independent arrival at the same conclusion as I have been arguing for, and by a different route.

It is worth noting, finally, that none of the alternative theories of dyslexia seem to be able to have predicted the finding that there is no deficit in (suprasegmental) representations. The respective contributions of these alternative theories to the larger question of how to pinpoint the cause or causes of dyslexia will be discussed further in §6.4, but it can be noted here that most theoretical alternatives to the Phonological Deficit Hypothesis share, with the Phonological Deficit Hypothesis, the assumption that there is a genuine phonological deficit, and one which they are content to accept as a deficit in phonological representations specifically. The Double Deficit Hypothesis, in particular, follows the Phonological Representations Hypothesis in assuming that there is a core phonological representations deficit – this hypothesis differs from the Phonological Deficit Hypothesis only in that it identifies speed of processing as a second core deficit. Relative to the other two main contenders, it is the Double Deficit theory which has perhaps slightly more to lose if the 'intact representations' position is adopted, because its model does intrinsically include impaired phonological representations. In the Magnocellular Theory and the Cerebellar Theory, however, much less emphasis is placed on the phonological deficit overall. The magnocellular theory assigns phonology only a limited role, acknowledging that there is some kind of phonological deficit but not making much of the question of representations; as a more biologically-oriented account, the cognitive aspects of dyslexia are less prominent in this theory. Similarly the cerebellar theory, to the extent that it can be considered in some senses as an extension of the magnocellular theory, is not overly concerned about phonological representations as such either.

Having now argued that phonological representations are the wrong place to look in the search for a deficit that plays a causal role in developmental dyslexia, I want to go on to propose in §6.3 something more positive along the lines that a more fruitful way of thinking about the phonology-related deficits in dyslexia is by thinking about metaphonological skills instead.

6.3 The role of metalinguistic skills in dyslexia

So far, in answer to the first question posed above, Are phonological representations impaired in dyslexia? I have been making the case that phonological representations are unlikely to be the source of whatever phonological deficit exists in dyslexia. Now that I have explained how the results of the various tasks have given some degree of support to this position rather than the alternatives, the second question named above can be seen to arise from the negative answer to the first: if my argument is valid and there is no deficit of suprasegmental or segmental representations in dyslexia, how then should we understand the role of phonology in dyslexia?

One option, if representations are not impaired in dyslexia, is to take a step away from mentalism and search for deficits perhaps more carefully in speech perception and/or production. From the production perspective, for instance, speech disorders in early childhood have been linked to later literacy disability in longitudinal studies (e.g. Lewis et al 2000, Locke et al 1997; see also Stackhouse and Wells 1997): although speech disorders are different from dyslexia, and dyslexia is widely defined in a way that excludes overt speech or language deficits, yet the qualification that speech and language deficits are not overt leaves open the possibility that there might be subtle deficits in dyslexia. From the perception perspective, auditory perceptual processing deficits have also been linked to literacy disability, and the contributions of Goswami (2006) and Stein (2001) in this direction will be discussed further in §6.4 below.

In the present section, the focus is on the option which was outlined in Chapter 1, relating to metalinguistic skills rather than representations. Here we look more closely at the role of metalinguistic skills, considered in themselves, as an alternative candidate to phonological representations for the basic locus of the phonology-related deficit in dyslexia. The suggestion of the hypothesis of Chapter 1 that basic metalinguistic skills (not including manipulation skills) could be at the source of the phonological deficit in dyslexia is examined in §6.3.1, as a possibility which could have salvaged some of the Phonological Deficit Hypothesis's commitment to a cognitive explanation for dyslexia. In §6.3.2 the question of the relevance of the manipulation deficit is examined in its own right.

6.3.1 Is metaphonological ability more important than representational quality?

The question of how metaphonological ability relates to representational quality was raised in Chapter 1, where it was noted that although 'phonological awareness' tasks are counted as crucial evidence in support of a representations deficit, and are known to be closely linked to reading skills, their relation to phonological representations cannot be assumed to be straightforward (§1.3.3). Bearing in mind that no difference was found between the two groups in the task which was intended to test basic metalinguistic skills, this section will discuss the question of the relationship between metalinguistic skills and representations (in §6.3.1.1), and the question of the relation between metalinguistic skills and reading (in §6.3.1.2).

6.3.1.1 The relation between metalinguistic skills and phonological representations

It was suggested in Chapter 1 that, rather than phonological representations, the metalinguistic analysis skills which are thought to underpin at least some aspects of successful literacy acquisition might be a more likely candidate for a phonology-related deficit which could play a causal role in the reading difficulties seen in dyslexia.

As noted above, the fact that no difference was found between the two groups in the Recognition task was counter to the expectation based on the Metalinguistic Hypothesis of Chapter 1, and it fails to corroborate the outcomes of some similar tasks, such as Bruck (1992) and Pratt and Brady's (1988) finding of deficits in adults with dyslexia in phoneme and syllable counting tasks, and the rhyme and alliteration judgment deficits found in adolescents by Fawcett and Nicolson (1995). It should be noted though that this was not an especially cognitively demanding task, and elsewhere in the literature it has been explicitly stated that more difficult tasks are required for studies with adult participants, particularly when the participants can be regarded as 'remediated' or 'compensated' (e.g. Pennington et al 1990). What can, therefore, be seen from the Recognition task is that whatever phonology-related deficit there may be in dyslexia, the further that theories locate it from phonological representations themselves, the more accurate they are likely to be: even basic metalinguistic skills are intact in this group, and differences between the groups do not appear until the more difficult manipulation tasks.

However, it does not seem that it would be appropriate to use the results of the Recognition to argue that basic metalinguistic skills themselves are unimpaired in dyslexia. The results were unexpected from the perspective of all three hypotheses, and it would seem either that the 'merely' metalinguistic nature of this task was insufficient to expose a deficit in the dyslexic group relative to the controls, or that the dyslexic group was already well practiced in making metalinguistic analyses. The precedent in the literature for finding deficits in adolescents and adults with dyslexia in tasks very similar to this one, along with the high theoretical importance assigned to phonological awareness in early development, mean that the present results are unlikely to be a reason to abandon the findings of the existing body of research into phonological awareness in dyslexia.

Yet if it is accurate to assume that dyslexia does involve a deficit in basic metalinguistic analysis (perhaps predominantly in childhood), the role of this skill needs to be interpreted carefully. Although it is extremely common in the dyslexia literature to find phonological awareness deficits being used as evidence for impaired phonological representations, the link between awareness and representations is not well-specified. Vellutino et al (2004) are representative of the writers who refer phonological awareness deficits back to underlying phonological representations. They say that compelling evidence in favour of a phonological *representations* deficit comes from,

> "training and intervention studies which have documented that direct instruction designed to facilitate *phonological awareness* and letter-sound mapping has a positive effect on word identification, spelling, and reading ability in general. In addition, poor readers have been consistently found to perform below the level of normal readers on *phonological awareness* and letter-sound decoding tasks …" (2004: 10, emphasis added).

I believe it is fully justified, as they go on to say, that these and similar findings "have led to a growing consensus that the most influential cause of difficulties in learning to read is the failure to acquire *phonological awareness* and skill in alphabetic coding" (2004: 10, emphasis added). However, I do not believe that it is legitimate to draw from this the conclusion which they present in the immediately following sentence:

> "Difficulties in acquiring phonological awareness and skill in alphabetic coding are believed to be due, in many cases, to weak phonological coding characterised by poorly specified phonological representations" (2004: 10).

What is done in making this jump from awareness to representations is basically to discount the possibility that it is the skill of phonological awareness itself that may be the basic underlying causal problem.

There are in fact two types of reason to think that phonological awareness is more likely as a locus for the reading deficit in dyslexia than putative underlying representations – and, so, to be concerned that the theoretical jump from awareness deficits to representations deficits is a step too far. The first is the fact that, theoretically and conceptually, phonological representations are a qualitatively different kind of knowledge from phonological awareness, and there are grounds to believe that the more subjective metalinguistic analysis is required of a language user, the more prone the analysis is to diverge from what is known from objective third-party observation to be the actuality of that language user's behaviour. This can be illustrated for example in the difficulties that are experienced by linguists who attempt to elicit grammaticality judgments from non-linguistically trained speakers of a given language. Although this kind of metalinguistic analysis is perhaps an extreme case of what is typically tested in dyslexia, it is known that a large variety of factors can influence the judgments given by speakers whose views are solicited on questions of the linguistic acceptability or wellformedness of sentences and other linguistic material – factors arising from the construction of the materials, the methods of presenting the materials, the judges' prior linguistic experience, and so on. Such problems are not restricted to syntax: in phonology too, caveats have been expressed about speakers' reports of their phonological behaviour (Pierrehumbert et al 2000). Speakers' informally expressed intuitions and introspections have also been regarded with caution, as Silverman (2006) makes clear in a discussion with reference to the writings of Bloch and Trager: "we can't determine the structural properties of linguistic sound systems based on how people feel about the sounds they use" (2006: 6).

Of course many of the difficulties associated with eliciting reliable wellformedness judgments from non-linguistically trained speakers of a language can be (and to an increasingly large extent are being) mitigated through the use of carefully designed elicitation techniques (e.g. Bard et al 1996) and through sensitive interpretation of the elicited data – and of course also, wellformedness judgments are to some extent a different kind of metalinguistic behaviour than, for instance, asking children to count how many sounds there are in the word *cat* and spoonerise John Lennon. But in practice the difference is one of degree, not of kind, as the question remains one of, on the one hand, having the informant analyse the form of the linguistic material without reference to its meaning, and on the other hand, analyse it in such a way that fits with the analytical constructs which the linguist is using and hopes are being grasped by the informant. The analytical construct might be 'phonemes' or it might be 'legality with respect to a grammar', but both these constructs and whatever lies in between are not necessary for speakers to be conscious of in order for communication to be successful, and the process of making speakers conscious of them and able to articulate their consciousness of them is not only something which must be done artificially in isolation from a discourse context but also something which is liable to result in inaccurate and distorted descriptions of how speakers behave automatically in natural speech situations and of how their implicit knowledge is organised and functions when not subject to conscious introspection. Speakers' metalinguistic analysis (of the structure or of the wellformedness of a piece of linguistic material) gives rise to different kinds of data about a different kind of speaker knowledge than does observing the spontaneous speech which speakers produce and/or testing their implicit knowledge and processing, for example. Speakers' metalinguistic reflection on language can therefore not be taken as an unequivocally informative guide to their actual linguistic behaviour, or indeed, whatever implicit mental representations of language they might have underlyingly. As Tunmer and Herriman (1984: 27) have pointed out, "treating the language system as an object of thought … is not an automatic consequence of using the system as a vehicle for communication," and the disconnect between *just using* language and *thinking about* it needs to be taken seriously.

The other main reason which I will advance here in support of the view that metalinguistic analysis seems a more promising place to identify, instead of phonological representations, as the locus of the key deficit in dyslexia, is the compelling evidence which was cited by Vellutino et al (2004) above – that individuals with dyslexia are, from childhood and into adulthood, characterised by a deficit in phonological awareness. Phonological awareness is what is explicitly tested in the vast majority of the studies referenced and alluded to by Vellutino et al's (2004) review, if not all of them – whether in the guise of what I have been calling 'merely metalinguistic' tasks or with the additional manipulation demands which I take as a different class of tasks – and it is in phonological awareness tasks that individuals with dyslexia are frequently found to be impaired. As pointed out earlier, it is the metalinguistic character of these tasks, and the great paucity of tasks which investigate representations per se, which to a large extent motivated the present study – but what the results of these metalinguistic tasks are positively telling us should not be overlooked.[5]

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[5] That is, as long as 'phonological awareness' is understood as the result of individuals converging on the socially agreed (and alphabetically determined) conventions for how to divide up the acoustic signal into categories (rather than working towards pre-existent units or segments which are somehow embedded as such in the speech stream), my view of 'phonological awareness' is not hugely different from how it is understood by dyslexia practitioners in the literature – but where I do diverge from the majority of the rest of the literature is in stopping right at this point – at the deficit in metalinguistic skill – rather than tracing metalinguistic deficits back any further, to linguistic representations.

This is in fact essentially the same argument as has been put forward by Ramus and Szenkovits (2008), who point out (in support of their position that access to representations rather than representations themselves are the real phonology-related impairment in dyslexia) that the critical pieces of evidence in support of this position "have been around for a long time" (2008: 138). They cite, for instance, the inconclusive nature of the existing categorical perception studies, and the fact that as Swan and Goswami (1997) found in the series of tasks which they presented to dyslexic children, performance of the dyslexic children did not differ from the non-dyslexic children when the participants' familiarity with the presented words was taken into consideration. Rather than implicating metalinguistic awareness alone, though, when they make suggestions for how the Phonological Deficit Hypothesis should be revised in the light of such findings, Ramus and Szenkovits make a broader suggestion, framing the deficit in terms of one of general access to phonological representations. This access could be required for purposes of metalinguistic analysis, but it could also be required for short term memory processes, or under speed constraints:

> "the phonological representations of people with dyslexia are basically intact, and the phonological deficit surfaces only as a function of certain task requirements, notably short-term memory, conscious awareness, and time constraints. In an attempt to reformulate those task requirements more economically, we propose that they have a deficit in access to phonological representations" (2008: 139).

There does indeed seem to be a significant role for both speeded processing and short term memory ability in dyslexia, as will be discussed later (§6.3.2 and §6.4), but for the time being my discussion will treat these separately, focusing on the fact that the need to step back and think about the form of auditory words itself distinguishes metalinguistic ability itself from any additional cognitive demands which may be made in the form of time or memory constraints.

Of course, although awareness is not the most immediately useful means of getting insight into phonological representations, it is not at all a trivial skill. It, or something similar to it, is usually included in the list of 'design features' for human language, for example – either under the rubric of '(total) feedback' (the term referring to the ability of the users of a language to monitor what they are transmitting) or 'reflexiveness' (which refers to the fact that in a language, one can communicate about communication). Perhaps more relevantly, it is also very closely related to reading acquisition, as studies from at least Bradley and Bryant (1983) onwards have shown. What this implies is that if awareness rather than representations turned out to be one of the core problems in dyslexia, this would not at all result in a dead-end for cognitive explanations of dyslexia – it would at the least keep open existing avenues of research interest, yet giving perhaps greater prominence to the insight into cognition that takes seriously the difference between implicit knowledge of the patterns of spoken language and the metalinguistic ability to think about the forms of spoken language as an end in itself.

So to reiterate, in concluding this part of the argument, I do not dispute that there is some phonology-*related* deficit in dyslexia: what I would like to challenge is not the empirical results of decades of research into phonology-related skills in individuals with dyslexia, but only the interpretative extrapolation from impaired 'awareness' to impaired *representations*.

6.3.1.2 The connection with reading

Having said this, some further discussion is required of the role of metaphonological skills in learning to read. As I have been arguing (e.g. §1.3.2), when children come to learn to read and write, they are not undertaking a process of matching orthographic symbols on the page with pre-existent phonological units in their mental representations or in the speech stream. Rather, they are bringing their existing implicit knowledge, which is not yet organised segmentally in any systematic way, into line with the segmentations provided in orthography – shaping their existing knowledge into 'phonemic' categories simultaneously with learning the sound values for particular graphemes. This is what allows their implicit knowledge that *bat* and *mat* mean different things to eventually take the shape of conceptualising 'the sound b' and 'the sound m'. Whether the ability to reflect on the form of spoken language is a pre-requisite or a co-requisite of literacy success, the ability to conceive of spoken language in terms of phonemic segments such as 'b' and 'm' is a by-product of literacy acquisition. On the other hand, there is no need or incentive for speakers to organise their implicit knowledge that *'toy factory* means something different from *toy 'factory* into any fixed form, and having no fixed conceptualisation of this difference in terms of 'the DA-da pattern' versus 'the da-DA pattern' has no consequences in either the spoken or the written domains.

But where in this process there is a role for metalinguistic analysis is not necessarily a straightforward question. Conceiving of the reading acquisition process as one of shaping spoken language knowledge along the lines of written language gives rise to a variety of implications, one being that a relationship should be expected between literacy measures and segmental metalinguistic tasks – that is, awareness of the very segments which are required for alphabetic literacy should correlate well with a measure of alphabetic literacy. Although the correlation of performance in the segmental Recognition task with performance in the WRAT measures did not reveal any significant results, this is no doubt due to the experimental task being relatively easy for the participants in question, as other studies with a developmental focus have indisputably shown that phonological awareness is both associated with reading achievement and also predictive of future reading achievement (as reviewed by, for instance, Goswami and Bryant (1990) for segmental awareness). The study by Whalley and Hansen (2006) which was mentioned in Chapter 1 (§1.3.4.1) is also relevant, in that the 'DEEdee' task used in their study was fairly similar to the suprasegmental Recognition task in the present study. For the nine year olds in Whalley and Hansen's study, the ability to accurately identify whether a phrase such as *Cinderella* should be matched with

DEEdeeDEEdee or DEEdee deeDEE, for example, was significantly correlated with measures of reading comprehension, reading accuracy, and word identification (regression analyses showed that it was most strongly related to reading comprehension) (it should also be noted that conventional segmental phonological awareness tasks such as phoneme oddity judgments also correlated with these reading measures in the same study, and were predictive of word identification, word attack, and reading comprehension skills). Yet, as was pointed out in Chapter 1, it is immediately evident that tasks such as this have no direct relation to reading. Results such as this suggest that general proficiency in handling the sounds of language is associated with increased proficiency in dealing with written language, but being able to identify the stress pattern of a word or phrase (whether it has its complete segmental content, as in the Recognition task, or whether the stress pattern is isolated from the original segmental content and superimposed on carrier syllables such as 'DEE dee') cannot translate into being able to identify or use the written counterparts of these words.

If these results for suprasegmental awareness are accepted as being parallel with the results for segmental awareness, then it could be argued that the connection with reading abilities may be as direct or indirect in both cases – that is, just as it is relatively obvious that suprasegmental awareness is indirectly related to reading ability, perhaps it should also be accepted that segmental awareness is also indirectly related to reading, or at any rate that it does not necessarily have any causal connection with reading. This is argued in at least two fairly recently published articles from rather different theoretical perspectives – Scholes (1998) and Castles and Coltheart (2004). The argument presented by Scholes is almost entirely theoretical, and his theoretical standpoint is in several places disconnected from what might be regarded as the main stream of dyslexia research. He defines reading very much in functional terms, with a heavy emphasis on comprehension, and in a way that therefore prioritises silent reading over the ability to sound words out – nonword reading, in particular, is dismissed as more or less irrelevant to reading in this sense. In this article the statement is made categorically that, “it is certainly not the case that phonological awareness is required for reading” (Scholes 1998: 183). Instead, it is pointed out that although phonological awareness may correlate with decoding ability, this is on the one hand largely dependent on letter-sound correspondences and on the other hand largely unrelated to whether or not the reader is able to understand the written text. In Scholes’s view, what makes it seem as if there is a causal relationship between phonological awareness and reading is the fact that reading is defined not in terms of comprehension but in terms of decoding or ‘sounding out’, whereas this definition is more or less self-serving. He argues instead that if reading was defined in terms of comprehension, decoding would become much less important, and so phonological awareness would be seen to be more or less irrelevant (or at least more independent).

Virtually the same conclusion is arrived at by Castles and Coltheart (2004), after undertaking a detailed examination of the various studies which have investigated the possible relationships between reading skills and spoken language skills. As they point out, in the vast majority of cases, the thought which has gone into this issue has involved the assumption that there is “a causal link between phonological awareness and reading in one direction or another” (2004: 102). They state that they are,

> “at pains to emphasise … that it is also possible that at least some of the documented association between phonological awareness and reading may not reflect a causal relation in either direction,”

and instead, “the ability to perceive and manipulate the sounds of spoken language does not assist literacy acquisition, nor does the acquisition of reading and spelling affect phonological awareness” (p102). Castles and Coltheart draw on Ehri’s notion of an amalgam of spoken and orthographic information, mentioned above (and reflected in §1.3.2), and suggest that perhaps the association between phonological awareness and reading skill (especially as measured by word reading or decoding tasks) “arises because both are, to a greater or lesser degree, indices of orthographic skill" (p102). This is essentially the same argument as will be advanced below in relation to segmental manipulation tasks, and it echoes what was argued by Scholes (1998).[6] Although Castles and Coltheart are very careful to emphasise that their argument does not and is not intended to undermine the importance of teaching letter-sound correspondences, they do argue that the available evidence is not sufficient to demonstrate that "teaching an explicit awareness of phonemes in isolation from graphemes assists reading acquisition" (p102), and ultimately, they query whether or not phonological awareness should simply be regarded as "one of the many interesting, but not necessarily causally connected, cognitive correlates of reading and spelling achievement" (p102).

By way of concluding this section, before moving on to consider the manipulation deficit, the discussion of this subsection should be brought to bear on what was said in the previous subsection. In §6.3.1.1 it was suggested that if there it is appropriate to identify *any* phonology-related deficit as the *cause* of the reading disability in dyslexia, it should not be representations but it could be metalinguistic skills. From the discussion of the present subsection it can be seen that the emphasis should perhaps be placed on the *if* for the time being – more evidence is needed, in at least the carefully defined conditions which Castles and Coltheart (2004) recommend, before it will be possible to say whether metalinguistic skills are associated with reading ability in such a way that the impairment of metalinguistic skill can be assigned a causal role in reading disability. In the light of the results and discussion

[6] Harris (2000) says that what distinguishes a literate from a pre-literate culture is, "not so much the *addition* of a quite separate mode of verbal communication as the *incorporation* of oral communication into a higher-order semiological synthesis involving the written sign. In that synthesis, however, it is increasingly the graphic element which dominates" (2000: 212). Clearly the worldview which Harris expounds in his 2000 book is radically different from the framework underlying the models which Castles and Coltheart operate with, but the concept of the written and the spoken fusing together so as to become indistinguishable in practice although possibly remaining conceptually separable seems to be what Castles and Coltheart (2004) are veering towards. Although Harris would not subscribe to formulations involving individual speakers' mental representations, his point here is potentially extendable to the distinction between readers and pre-readers in development, though with the difference that pre-reading children still belong to literate societies.

presented so far, the smallest possible change which it seems advisable for the Phonological Deficit Hypothesis to make would be to explicitly implicate metalinguistic skills rather than phonological representations, but it is not yet clear that this is the only change that is required in this influential account of the reading deficit.

6.3.2 What is the relevance of the manipulation deficit?

Having discussed the role of basic metalinguistic analysis, we turn now to discuss the relevance of the deficit which is demonstrated by individuals with dyslexia in phonological 'manipulation' tasks. As has already been outlined, in the Phonological Deficit Hypothesis, the manipulation of particular phonological units is assumed to be dependent on how good the representation of that unit is in the mind of the speaker carrying out the task, whereas on the other hand, the view presented in Chapter 1 treats manipulation tasks as different from basic metalinguistic analysis, which in turn relates to phonological representations only indirectly. The second of these views is supported by the findings of the present study, where the dyslexic group's performance on the task demanding implicit knowledge of the meaning of words which were differentiated by segmental contrasts was at ceiling, and their knowledge of words differentiated by suprasegmental 'contrasts' was equivalent to that of the control group (and similarly for the task which demanded basic metalinguistic analysis of a word or phrase to identify a unit within it), and yet the dyslexic group's ability to manipulate both types of phonological unit was impaired relative to the control group's. This suggests that the deficit shown by the dyslexics in the manipulation tasks is unlikely to be particularly closely dependent on either their representation of these units, the concept that isolatable units can be identified within words, or the ability to isolate the specified within-word units. Instead, therefore, we need to consider in greater depth the various other skills which the manipulation tasks involve.

6.3.2.1 The cognitive skills demanded by manipulation tasks

In contrast to the Interpretation task of Chapter 2, the manipulation tasks make a very different use of the segmental and suprasegmental units on which the minimal pairs were based. While the Interpretation task invoked these units more or less implicitly, the manipulation tasks necessitated a movement away from utilising their function in this implicit (and meaning-related) way, so as to consider them much more abstractly – not, as in the Interpretation task, as creating (or marking) a meaningful difference between words, but rather as units in their own right which need to be isolated and handled as distinct components of the words or phrases which they happen to occur in, for the purpose of carrying out further operations with them. The manipulation involved a highly detailed level of segmentation, the ability to completely dissociate arbitrarily selected units of sound from the words they occur in, and also the ability to move these arbitrarily extracted units to a new phonetic/phonological context and make them fit in there, in a phonetically and/or phonologically acceptable way. The crucial skills for the manipulation tasks can therefore be identified as segmenting words into units, manoeuvring the units, and combining the units with the phonological material in their new phonological context. Each of these three skills is perhaps especially critical in the conventional production-oriented paradigm for manipulation tasks where participants are required to produce the manipulated (pig-latinised or spoonerised) forms themselves, but each of them continues to play a more or less critical role in recognition-oriented paradigm which was used in my experiments (where participants had to recognise the finished product but not actively produce the forms themselves).

The significance of this point can be seen from the nature of these three different sub-skills needed for the tasks. Firstly, the segmentation which these tasks demand is artificial, for instance, in the sense that segment boundaries cannot be directly observed in the speech stream but must be imposed on it by the language user or language analyst, and in fact, the segmentations required for these tasks were not only artificial but also arbitrary – the first consonant in a cluster and the 'main stress' (divorced from syllabic content) are not components which a word naturally falls apart into, and were in fact only specified in the task instructions on an arbitrary basis. Additionally, what is required for the manoeuvring of the sounds required by these tasks is an ability to take the segmented units and treat them as if they were independent of the (phonetic/phonological) context in the word in which they were presented and in which they really belong – a feature of the task which involves both a familiarity with the units as part of the language system, rather than merely the knowledge of what these sound patterns mean when they are part of a word in a discourse context, as well as the ability to recombine the units in a new location in the word. This third component of the task, that of recombining or blending the units in their new phonological context, is a reconstruction of units which are identified only through prior segmentation, and something which also demands an understanding of so-called allophonic and coarticulatory phenomena for the types of sounds in question. Of course this point would have been more weighty if participants had been required to produce the resulting forms themselves, but even as things are, participants still needed to recognise the identity between cluster-initial /b/ and pre-vocalic /b/ in the pair *blanket*, *lanket-bey* for example, and the identity between main stress on the syllable /fɪk/ and main stress on the syllable /ke/ in pairs such as *fictional*, *volcano*).

All these characteristics of the skills which a participant needs to be able to bring to bear on the manipulation tasks go to show that the abilities which such tasks demand is rather remote from everyday speech perception and production and everyday spoken communication in general. These are tasks which presuppose or expect a kind of knowledge which can be described as either (i) a facility with the type of analysis of the form of English words that breaks them into these units, i.e. the knowledge that the phonetic/articulatory sequence [bla…] or [b̚la…] or [bɫã…] or however it might be produced and notated, can be broken into /b/ plus /l/ etc; or (ii) a familiarity with these units as part of the language system, i.e. the knowledge that /b/ is not /p/ nor /m/, and that /ˈ/ (primary stress) is neither /ˌ/ (secondary stress) nor tertiary stress; or (iii) perhaps as both of these combined. That is to say, unlike in the tasks in Experiment 1, these tasks cannot be successfully undertaken simply on the basis of the auditory material which has been presented and the participant's knowledge of the word (and the world), but rather it is necessary for them to know how the relevant components of the presented items fit in with the rest of the language system as a whole. It is in other words a shift away from making use of auditory words to convey shared meanings in a real-world context (which is after all the most straightforward everyday use, if not raison d'être, of spoken linguistic material), and a corresponding shift towards a focus on form either in isolation from or at least distinct from meaning.[7]

In fact, this shift or inclination is even further reinforced in these tasks in that the end results of the different manipulation procedures were in each case nonsense words, not real lexical items. In this way the participants were forced to consider the units (and their eventual relations with each other after being manipulated) merely in terms of their form, and completely dissociated from their real world denotations.

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[7] Although it has been suggested (Snowling et al 1997) that the skills required in manipulation tasks are similar to those needed for learning new words, whether in a first language or a second language, this is not an adequate analogy, because in acquiring spoken language there is neither the need nor the opportunity to identify segments as such and treat them as individual units which can stand alone and be split up and creatively and/or arbitrarily recombined at will. And although these various aspects of the task (identifying segments as such, treating them as individual stand-alone units which can be combined with each other freely within certain conventional orthographic and phonotactic restrictions) do find some application when people come to interact with written text (whether reading or writing), the units in question in the context of written text are of course alphabetic symbols rather than arbitrarily specified portions of the spoken word.

To put this in another way: the word *blanket* would normally only be uttered in everyday circumstances when a blanket was being discussed in a context, where the phonemic or segmental components would be only one source of information as to the referent intended by the speaker (along with prosody and paralinguistic signals and indexical information and the discourse context at large). In contrast, in the manipulation tasks, the word *blanket* is presented, not only without a discourse context, but also with the intention that its meaning should not or need not be accessed at all, and for the purposes of first dissecting it as an object in its own right (as though it was natural for words to be examined without reference to their meaning) and then re-shaping it in a wholly arbitrary way. From this detailed breakdown of the task demands, it can be seen that there is good reason for saying, as was argued in Chapter 1, that tasks such as these are by their nature inadequate as a source of evidence about phonological representations because they are, by definition, remote from *representations* as such: it is much more appropriate to consider the manipulation deficit as a complex of skill deficits, not merely as the manifestation of a single or unitary problem such as an underlying representational deficit.

A final point for this section is to do with the role of working memory. In addition to the need for segmenting, manoeuvring, and blending the artificial and arbitrary units, it can be seen that manipulation tasks such as these also make some significant demands on short term and/or working memory. These demands were not made in the tasks described in Chapters 2 and 3, and they were in some ways increased in the tasks reported in Chapters 4 and 5 relative to their conventional alternatives as a result of the methodological format which they took in this particular study. As already noted, in their typical instantiation (for instance in the Phonological Assessment Battery (PhAB, Frederickson et al 1997) or in less formalised batteries of phonological tests used in studies such as Gottardo et al 1997), manipulation tasks such as pig Latin and spoonerisms involve participants making a spoken response to the presented words in the terms of the manipulation procedure, whereas here in the present study, participants were not required to make a spoken response – instead they heard the original wordforms, followed by a possible spoonerism or pig latinised form, and what they had to do was to judge whether the modified form was indeed a true spoonerism or pig latin form according to the terms of the task instructions. Although this kind of task format reduced the need to assemble a motor output, it still meant that participants were required to hold in mind both the original form and the extracted part of that word, as well as re-enacting the steps of the manipulation procedure in order to compare the output form with what it should have been according to the task instructions.[8] This is markedly more complex than what they had been asked to do in the Interpretation and Recognition tasks, and it may well be the case that phonological manipulation tasks such as these might be better seen as more of a working memory test than a task that can be particularly revealing about phonological representations (and no more 'phonological' in the linguistic sense than tasks such as digit span, where short-term memory is tested using spoken material but where the phonological structure and the meaning of that spoken material is treated as more or less irrelevant). Similar observations are made by Fawcett and Nicolson (1995), who point out that in addition to phonological awareness, tasks such as Pig Latin is also dependent on "processing speed (each subtask must be accomplished in the context of a rapidly fading memory trace), working memory capacity and/or general processing efficiency" (1995: 364).

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[8] In relation to task instructions and the memory requirement, note that Downey et al (2000) report that in their study, the Pig Latin procedure was explicitly presented as a "four-step operation," where participants were "asked to segment the initial sound from the word, place it at the end of the word, add 'ay' to it, and phonetically blend the resulting string" (2000: 106). In comparison with the instructions in the present study, this gave participants an extra step to perform – phonetically blending the resulting string – which was not flagged up to participants in the present study as a separate step in its own right ("the word should have its very first sound chopped off and moved to the end of the word. When that sound is at the end of the word, it should be attached to the sound 'ey' to make a new syllable;" see Appendix D). The outcome of both instructions is the same, of course, but in the present study while the list-like step-wise method of carrying out the procedure was available to participants to use, it was not particularly emphasised.

Up to a point, it is possible that orthography itself may play a supporting role in the recall or manipulation of spoken material which can be represented orthographically. Conventional orthography gives people a hook to hang things on – it is a ready-made metalanguage (if not *the* metalanguage) for dealing with the sounds of speech, a convenient way of structuring auditory speech information in a way common to the rest of the population, and one which the majority of people in this society have spent a great deal of time and effort being trained in. Stahl and Murray (1994), for instance, comment that even tasks such as tapping out the number of phonemes in a word "may put an unreasonable load on short-term memory unless the word is mediated by its spelling" (1994: 223), and in the context of serial recall tasks, Roodenrhys and Stokes (2001: 391) suggest that "learning to read produces representations of words which can be accessed by other processes to support performance." In principle, then, orthography is an obvious source of support for a literate individual to call on when confronted with spoken language.

With this in mind, however, it is not yet clear whether the deficit in verbal short-term memory which has been observed in dyslexia even in adults (see e.g. Rack 1997) is due more to the 'phonological' aspect of these tasks or the 'memory' aspect. Several studies have found deficits in dyslexia in either digit span or nonword repetition tasks, or both. Although these deficits are frequently taken as relevant primarily to the putative phonological representations deficit (for one example, Ramus et al (2003) collapse nonword repetition accuracy along with spoonerisms into a single composite 'phonology' variable), it may be more useful to keep the phonological aspect of these tasks distinct from their working memory aspect. As Pennington et al (1991) point out, even from a developmental perspective it would seem that verbal short-term memory and/or working memory is a skill which develops prior to skills such as phoneme awareness. The question of whether individuals with dyslexia are impaired in visuospatial aspects of working memory as well as in verbal or phonological aspects has been addressed in a handful of studies. One, a study of 10 year old reading disabled children, found no difference between the reading disabled children and control groups in visuospatial tasks such as recalling a series of dots presented in a matrix, recalling the sequence and location of three geometric shapes, and the spatial organisation of cards with different shapes (Swanson 1993). However, there is also some evidence that visuospatial aspects of working memory may be impaired in dyslexia. Rumsey and Hamburger (1990) presented adults with and without dyslexia with the Wechsler Design memory task, where participants are shown three cards with designs and asked to draw the images either immediately after seeing them or after half an hour's delay. Although there was no difference between the groups in the immediate recall condition, in the delayed condition, the dyslexic group recalled less information than the control group. Similarly, a recent study by Smith-Spark et al (2003) has also found that under sufficiently taxing conditions, adults with dyslexia also show a deficit in visuospatial tasks, including in so-called 'updating' conditions (where participants are required to recall the last four items in a list whose length is unknown to the participant, requiring constant updating of what counts as the last four items; lists in Smith-Spark et al's study ranged from 4 to 10 items in length) – the main significance of 'updating' tasks being that they are generally thought not to involve any reliance on the 'phonological' aspects of the working memory system.

If indeed it is the case that, in addition to the well-recognised verbal short term memory and working memory deficits, difficulties with the recall of visuospatial information are also a characteristic of dyslexia, then a case could be made for saying that it is not the phonological aspects of tasks such as nonword repetition, spoonerisms, and so on, which makes them difficult for individuals with dyslexia, so much as their requirement for memory resources. In other words, whatever use a knowledge of orthographic conventions can be put to in support of the recall or manipulation of auditory information, the point where tasks which demand too much of a facility with construing speech in this way could be at least as much to do with their increasing memory demands, which overtax the use which dyslexics can make of this resource, than the fact that an orthographic representation is available but inadequately accessed, for example. This would also explain why the dyslexic group in the present study performs less successfully than controls in the suprasegmental versions of the two manipulation tasks as well as the segmental versions, given that the suprasegmental elements which they are required to manipulate have no orthographic notation to either help or hinder performance.

6.3.2.2 Manipulation tasks in relation to reading

We turn now to the relevance of manipulation skills to reading. Several studies have been published which report a relationship between performance on (segmental) phonological manipulation tasks in general and literacy achievement. Some of the main ones of these were reviewed in Chapter 1 (§1.2.1.2). In adulthood too, as has been mentioned in Chapters 4 and 5, a handful of studies have shown that performance specifically on segmental pig Latin and spoonerism tasks is associated with literacy ability. Gottardo et al (1997) showed that pig Latin accuracy was correlated with WRAT Reading in adults with dyslexia (they also found that pig Latin accuracy was a unique predictor of nonword reading ability). Ramus et al (2003) found that a composite 'phonology' variable was an excellent predictor of a composite 'literacy' variable for a group of university students with dyslexia, although the interpretation of this finding is perhaps less clear-cut than is acknowledged in the study itself, since the 'phonology' variable was a composite of not only accuracy and response time in the spoonerism task but also picture and digit naming latencies, nonword repetition accuracy, and performance on a standardised working memory measure. (The 'literacy' variable was a composite of the WRAT Reading and Spelling subtasks, a test of reading rare and irregular words, a nonword reading test, reading speed, and two syntax measures.) A third study, by Judge et al (2006) found that spoonerism accuracy (along with phoneme deletion latency, separately) was correlated with WRAT Reading scores in a group of university students with dyslexia, while for the control group of non-dyslexic students in this study, WRAT Reading performance was correlated with a phonological composite which included spoonerisms, phoneme deletion latency, and rhyme fluency (none of which was significantly correlated individually). The results of these studies combine to suggest that manipulation skills are indeed relevant in some way to literacy skills (apparently particularly reading).

By and large, the results of the present study are in keeping with these previously reported findings. This is particularly evident in the case of the segmental Spoonerism task, which was strongly correlated with both WRAT Reading and Spelling for the dyslexic group (and with Spelling, and nearly with Reading, for the control group). The Pig Latin results were similarly consistent with this picture: accuracy in the segmental version was correlated with Reading (though not Spelling) for the dyslexic group, while for the control group, segmental accuracy was only nearly significantly correlated with Reading.

In addition, the contribution of the suprasegmental tasks is also important. The correlation between suprasegmental Pig Latin accuracy and Reading was significant for the control group and approaching significance for the dyslexic group, while the correlation between suprasegmental Spoonerism accuracy and reading was significant for the dyslexic group and approaching significance for the control group. The importance of establishing relationships such as these is that although the suprasegmental manipulations were as closely modelled on the conventional segmental manipulations as was feasible, there is no immediate reason to expect that there should be a relationship between literacy and the suprasegmental tasks (given that suprasegmental information is neither directly useful for literacy acquisition in English nor amenable to orthographic representation). The Phonological Deficit Hypothesis in particular, because it relates segmental manipulation deficits to reading through the alphabetic principle, requires attention if it is to be able to integrate the relation between suprasegmental phonology and reading performance into its hypothesis.

However, the relationship between literacy and segmental manipulation skills also requires closer attention. There are some requirements which are shared by both successful literacy acquisition and success in segmental manipulation tasks – such as the need to be able to focus on the form of auditory words, and the need to segment the words into the requisite units. Yet these analyses are undertaken for different purposes in each case. Whereas in the case of reading, the purpose is so as to bring knowledge of spoken language into line with the conventions of written language, and in this way to set up grapheme-to-phoneme correspondences, in manipulation tasks, the purpose is so as to move the target units to a new position and recombine them with the sounds in their new location. So when speech sounds are segmented in the context of literacy (acquisition), it is done with a view to eventually accessing meaning – in contrast to the segmentation undertaken in the context of manipulation tasks, which is wholly artificial and divorced from meaning. As mentioned previously, though, one further commonality between these two skills is that the segmentation has to be in a sense *total* – it is not enough to be able to identify segments within the words, but the segments have to be treated as entirely independent units – individual stand-alone units, able to stand in any relation to any other unit in the system subject only to phonotactic and orthographic constraints. (This, it would seem, is the feature of manipulation tasks which distinguishes them from the *merely* metalinguistic analysis which was required in the Recognition task, where a focus on form was required, along with a need to segment the forms, but there was no need to extract the segmented units so as to manoeuvre and manipulate them in their own right.)

What has to be done in manipulation tasks, then, is to treat speech as if it had the properties of written text, but at the same time translate freely between the properties of written text and the application of those properties to spoken language. However, the ability to do this may not be any more revealing as to the relationship between phonological manipulation and the reading process than the fact that it is parasitical on the skills acquired for successful engagement in a literate environment. This could help to interpret the results of the suprasegmental versions of the manipulation tasks in the present study. In both segmental and suprasegmental manipulation tasks, what is key is the ability to isolate and manoeuvre arbitrarily segmented components of what is otherwise a complex whole, the segmentation being carried out in both cases differing only in that it is done vertically in the case of phonological segments and horizontally in the case of suprasegmental units. In relating this ability to reading, the choice of interpretations is between the following. On the one hand it could be said that it is the segmentation itself which is common to both segments and stress that is being reflected in the association with reading, that is, the ability to view whole words as being potentially divisible into either units such as stress or units such as segments. In this case it could be said that experience with literacy provides an incentive, and an example of how, to analyse the sounds of spoken language, which is directly relevant in the case of segments and 'in principle' in the case of suprasegmentals. On the other hand, it could be the case that segmental manipulation and orthographic competence are entirely mutually reinforcing and suprasegmental manipulation is related to literacy proficiency in approximately the same way as, for instance, processing speed has been found to be (Wolf et al 2002), that is to say, at a greater conceptual or theoretical distance than segmental skills, with the difficulty of this task for individuals with dyslexia arising primarily from further cognitive or processing requirements (such as in this case the need to isolate and manoeuvre units in working memory).

These options confront the Phonological Deficit Hypothesis with a dilemma, as in either case some revision to its formulation is required: either segmental manipulation tasks are not as revealing of the phonological deficit in its relation to reading as has been thought, or else more distantly related skills which are nevertheless associated with reading play more of a role than the current, specific-to-representations, formulation of the theory recognises.

6.4 The search for the causes of dyslexia

The Phonological Deficit Hypothesis is explicitly a theory of the cause of dyslexia: "the specific reading retardation characteristic of dyslexia is directly and exclusively caused by a cognitive deficit that is specific to the representation and processing of speech sounds" (Ramus 2003: 212; see also White et al 2006: 253). But although this approach has the benefit of straightforwardness and simplicity, its weaknesses are, on the one hand, a scarcity of evidence which has a bearing directly on the question of phonological representations as such in dyslexia (as has been discussed previously), and, on the other hand, what Wolf et al (2002) call "the tendency to subsume other possible explanatory processes under the rubric of phonological processing" (2002: 44). This section will discuss relatively briefly the merits of the main alternative theories of the causes of dyslexia.

Of course, arguing as I have done that it is inadequate for the Phonological Deficit Hypothesis to include phonological representations in its central claim does not directly address the issue of causation. However, raising questions about the role of representations brings with it a train of further questions relating to the role of phonology in general, and in particular whether it remains plausible to conceive of even more 'distantly phonological' or phonology-related impairments as being the direct and exclusive cause even of the specific reading disability characteristic of dyslexia. The burden of the argument so far entails that as long as the kind of phonological skills which are involved in the deficit are inseparable from those which have counterparts in written text, this kind of phonology-related deficit is inherently implausible as a cause of reading impairment.

This is disputed, however, in various places in the writings of proponents of the Phonological Deficit Hypothesis. It has been argued, for instance, that it is inappropriate to characterise the phonological deficit in dyslexia as related only tautologically to the reading deficit, mainly since the phonological deficit extends beyond phoneme awareness to skills such as rapid naming and verbal short term memory, which are apparently independent of phonological awareness and additive (Ramus 2003: 215). White et al (2006) also cite verbal short term memory and rapid lexical retrieval as included alongside phonological awareness under the label of the phonological deficit and "not reciprocally related to reading" (2006: 251). However, this argument sits uneasily with the claim that it is phonological representations which are basically impaired in dyslexia, since although both rapid naming tasks and verbal short term memory tasks make some reference to phonological skills, they both involve much more than phonology alone (§1.3.3): it weakens the claim relating to phonological representations when the evidence that is adduced in its favour is no more direct or specific than rapid naming and verbal short term memory performance, particularly when (especially in the case of rapid naming) there is a large and growing body of evidence that what makes these tasks difficult for individuals with dyslexia is their speed demands and their memory demands. Nor indeed does this argument address the real nub of the problem, which is that whether or not some way could be found of isolating the phonology-related component of not only phonological awareness but also rapid lexical retrieval and verbal short term memory, this itself is the very source of the alleged confound with orthographic knowledge.

In conjunction with conceptual difficulties such as this, the criticism of Wolf et al (2002) (that the proponents of the Phonological Deficit Hypothesis are too prone to collapse diverse skill sets under the one rubric of phonological processing even when some of these skills are themselves potentially explanatory) becomes particularly forceful. Some other possible explanatory processes were alluded to above in passing. For instance, auditory perceptual deficits, after being mooted in the past as a possible cause of impairment and falling out of interest, have recently begun to be re-identified as potentially relevant to literacy disability. Goswami et al (2002) showed that detection of rhythmic beats in amplitude-modulated signals is poorer in 9 year old dyslexic children than their chronological age controls; this rhyme detection ability was able to explain 25% of the variance in reading and spelling after age, IQ, and vocabulary were controlled for, and also after controlling for phonological skills (as measured by a rhyme oddity task, a nonword repetition task, and a rapid automatised naming task). The connection between beat detection ability and reading which is proposed by Goswami et al (2002) is linked with claims relating to the role of syllable awareness in spoken language acquisition and reading acquisition. Specifically, the syllable is taken to be the basic unit of speech, which children become aware of first of all in development, and which in English is a more useful unit for mapping to print than is the phoneme (since English orthography is more consistent at the rime level than at the phoneme level; -*ight* and -*ake* have a more consistent sound value than *g* or *e*, for example). If dyslexia involves a deficit in beat detection, then it is argued that individuals with dyslexia will have difficulty in perceiving aspects of syllables in the acoustic signal, which will then impede the development of syllable awareness and onset/rime awareness, which will then slow down the child's ability to match letter sequences and rhymes, as well as their ability to learn grapheme-phoneme correspondences (see e.g. Goswami 2002, pp160-161, Richardson et al 2004).

The shift in approach which the research of Goswami and her colleagues exemplifies is a move away from exclusively cognitively based explanations towards accounts which make concrete connections with physical behavioural data. Although there is a widely used framework which sees different kinds of explanations as mutually helpful – Frith's (1997) view of biological, behavioural, and cognitive explanations as three legs of a stool – if these three types of description are genuinely supportive of one another and explanatory of the same phenomenon, there should be a way of linking them up to provide ultimately a unified account. This means that even though there are missing pieces of data and not all the connections are clear, still, in principle, the conclusions reached in one area should be compatible with those in another, and the immediate frame of reference which researchers in one area are working within should not as a matter of course prohibit or be immune to insights from another. However, there is only a certain point up to which any exclusively cognitive set of explanations can admit the kinds of data which are the staple of more behaviourally or biologically based explanations. The axioms and principles which underpin, if not the Phonological Deficit Hypothesis itself, yet certainly the general theoretical and philosophical background which it grew out of, are not always able to fit particularly comfortably with non-cognitive hypotheses and data. It reflects, presumably, the distinction between competence and performance – a distinction which is not held especially overtly or consistently within the framework of the phonological deficit, but which nevertheless colours and influences it.

This can be seen particularly in the way that there is no room for a role for auditory perceptual data to be incorporated into this hypothesis. This is not merely a question of whether auditory perceptual deficits need to be recognised as characteristic of all individuals with dyslexia. It is clear that deficits in categorical perception, beat detection, temporal order judgment, and so on, are not found in all individuals with dyslexia, although they may be present in perhaps a third to 45% of the sample in the various studies which have investigated them, and it is also clear that these deficits do not always show a particularly close relation to reading or speech-related skills (see the critiques by Ramus (2001) and Ramus (2003), e.g.). However, after the Phonological Deficit Hypothesis has ruled out a major role for subtle deficits such as these, it provides little in the way of alternative perceptual data which might be related to the phonological deficit. Instead, the causal elements of the Phonological Deficit Hypothesis are all channelled through the cognitive level of description: research into the possible biological bases of dyslexia is encouraged, and indeed abnormalities in the structure of the brain are brought into the model (e.g. by Ramus (2004)), but still the specific deficit which is causally related to reading disability is identified as cognitive. The tendency to refer naming speed deficits and short-term or working memory deficits back to phonological representations with little regard to the questions surrounding speed of processing and memory limitations is an outworking of the same tendency not only to subsume diverse phenomena under the one label of phonological processing but to treat the phonology-related element of these phenomena as primary and the other components of the requisite skills as barely relevant. Yet as Goswami (2006: 259) points out, this is unsatisfactory even from the point of view that the cognitive neuroscience research field in general "has yet to find a cognitive deficit that arises detached from any neural underpinnings in terms of sensory or perceptual problems."[9]

Whether or not the particular explanatory theory proposed by Goswami and colleagues can be accepted wholesale, this search for the 'neural underpinnings in terms of sensory or perceptual problems' is common to all the theoretical alternatives to the Phonological Deficit Hypothesis. This is indicated in the concerns of Wolf and her colleagues, as mentioned above. The particular process which Wolf et al (2000) had in mind as being inappropriately subsumed under the rubric of phonology was naming speed, and the Double Deficit hypothesis which Wolf and colleagues have proposed is careful to treat processing speed as independent of phonology (see §1.2.2.3 for a review). In their focus on expounding the role of

[9] This article by Goswami (2006) is a comment on an article by White et al (2006). As part of their response, the authors of White et al (2006) (i.e. Ramus et al 2006) respond by saying that the position articulated in the excerpt I have quoted here is "an article of faith, not a scientific result" (Ramus et al 2006: 267-268). This is true to the extent that it is an axiom which guides theory and research, but which can be neither proven nor disproven by "scientific results". Empirical data is always silent in the absence of a guiding theory: scientific results are always interpreted from the starting point of "articles of faith" in the non-pejorative sense; the alternative view to what Goswami articulates is every bit as much an "article of faith" itself. Comments such as this therefore do little more than sidestep the conceptual issues under discussion.

processing speed the proponents of this theory leave the causal role of the phonological component of the account more or less untouched, but the role of naming speed is well worked out. Specifically, the causal chain which is suggested by the double deficit hypothesis incorporates naming speed as a marker of a broader deficit in precise timing, a deficit which also manifests itself in the visual and auditory systems and in the coordination of visual and phonological systems (Bowers & Wolf 1993). Suggestions are also made for how this timing deficit could be traced back to possible physiological sources. For this aspect of the theory, Wolf et al (2000) invoke the magnocellular system, the system of large cells in the brain which is responsible for the timing of fast and transient sensory events (Wolf et al 2000). At this point the double deficit hypothesis draws on substantially the same evidence base as the Magnocellular Theory in making its causal claims – namely, the finding that post mortem examinations of dyslexic brains showed abnormalities in the magnocellular layers of the lateral geniculate nucleus, and the finding that the processing of visual images of low spatial frequency is slow and of poor quality in individuals with dyslexia (see e.g. Wolf et al 2000, with Stein & Talcott 1999).

The benefits of the double deficit hypothesis are therefore not restricted to its insight into the fact that the 'phonological deficit' is not as unitary as it is assumed to be from the perspective of the Phonological Deficit Hypothesis, and hence its resistance to the tendency to collapse everything that has a link with spoken language into 'phonological representations.' They also include the potential for a broad-based consensus that a magnocellular deficit has an important role to play in the causes of dyslexia, as not only does the double deficit hypothesis make contact with Stein and colleagues' magnocellular theory in this way but the proponents of the cerebellar hypothesis also assign a significant role to the magnocellular system in their theory. The cerebellar theory, of course, proposes to account not only for classic cerebellar deficits (such as postural stability and motor coordination) but also the timing difficulties identified by the authors of the double deficit hypothesis, and the reading deficit itself: difficulties appear in reading and spelling because these tasks "involve a combination of phonological skills, fluency, automatisation, and multitasking – a combination of all the skills that dyslexic children find difficult" (Fawcett & Nicolson 2001: 100). They also note that because of the close connection between the magnocellular system and the cerebellum (there are magnocells in the cerebellum and magnocellular pathways from elsewhere in the brain project to the cerebellum) it can be difficult to distinguish between the claims of their cerebellar account and those of the magnocellular theory. However, they argue that while the magnocellular theory is able to account for deficits in skills which require rapid processing, the cerebellar theory is also able to account for deficits in certain skills such as rhyme judgment which do not require rapid processing, through the role of the cerebellum in enabling skills to become automatised. On the other hand, the proponents of the magnocellular theory assign more importance to the visual and auditory transient systems. They diverge from Nicolson and Fawcett's position in that they see the impairment in the development of the magnocellular system as underlying the cerebellar deficit (Stein & Talcott 1999), but they do concur that the cerebellum has an important role not only in the acquisition of sensorimotor skills, including the control of eye movements in reading, but also for more generic language and literacy-related processes, citing findings which show that children with lesions on the right hand side of the cerebellum perform poorly on language and literacy measures, whereas children with left-sided cerebellar lesions tend to have visuospatial difficulties instead (Stein et al 2001).

On the other hand, the importance of the magnocellular system has also been called into question in favour of a parietal deficit instead. A study carried out by Amitay, Ben-Yehudah, Banai, and Ahissar (2002) has been argued to demonstrate that individuals with dyslexia do not show the range of the deficits which the magnocellular theory predicts, while they are shown to be impaired in functions which are not dependent on the magnocellular system. Instead, these researchers suggest that the range of deficits observed in dyslexia is better accounted for by higher-level attentional and memory systems, associated with the parietal region. It has also been observed that individuals with dyslexia do not benefit as non-dyslexics do from repeated exposure to stimuli (Banai & Ahissar 2006). Banai and Ahissar (2006) found that although individuals with dyslexia did not show a deficit in tasks where they had to undertake same/different judgments on tones or nonword minimal pairs, they did show an impairment when the same stimuli were presented sequentially for comparison (in judgments of which of two tones was higher, for example, or in an AXB task which required participants to state whether the second or the third tone or nonword matched the first one). They suggest that these deficits can best be understood as involving "mechanisms for operating on perceptual aspects of recently processed stimuli," which they gloss as approximately equivalent to working memory mechanisms (Banai & Ahissar 2006: 1724).

On the basis of this and other evidence, Ahissar (2007) has proposed the 'perceptual anchoring deficit' hypothesis, which suggests that dyslexia involves a deficit in the ability to register a recently encountered stimulus as a basis for comparison with future stimuli. For example, in a task where participants were asked which of two tones was higher, a group of 13 year olds with dyslexia did not differ from controls in the condition where both the tones were a different pitch on each trial. However, in the condition where the lower tone was always fixed at 1000 Hz, the dyslexic group's performance was weaker than that of the control group. Rather than forming a 'perceptual anchor' based on the recurring fixed low tone, which would have allowed them to identify any non-identical tone as the higher one, the individuals with dyslexia seemed to approach each trial as if no prior information was available, starting from scratch each time (Ahissar, Lubin, Putter-Katz, & Banai 2006). Although there are no direct commonalities between the present study and the anchoring deficit hypothesis and the studies which support it, because of the importance which this hypothesis attaches to working memory it seems to coincide with the view expressed here that it is not implicit knowledge but taxing working memory conditions which expose deficits between dyslexics and non-dyslexics in conventional phonological processing tasks (and to concur, in turn, with the view expressed by Ramus and Szenkovits (2008) that it is in the operations carried out on long-term memory representations, rather than the representations themselves, where the more significant deficit in dyslexia manifests itself).

To conclude, rather than expressing a view as to which of these alternatives might be a better way to account for dyslexia, I will here simply note that the overall tendency of these alternative theories is to look beyond the reading deficit in dyslexia to the wider range of symptoms seen in this impairment and attempt to draw up hypotheses which will be able to account for all the varied manifestations of dyslexia – they are careful not to equate dyslexia with reading difficulties, and so they cannot be satisfied with having explained the reading difficulties in terms of a phonological deficit. Even if a phonological deficit did explain the reading difficulties, the consistent position of these alternative theories is that there is more to be explained than the reading difficulties – and as I have been arguing, there is reason to query whether or not the phonological deficit can after all explain the reading deficit. The search for the causes of dyslexia, therefore, cannot stop with the Phonological Deficit Hypothesis.

6.5 Looking ahead

One important way of extending the results of this study will be to look at dyslexia in individuals who are not university students. As was reported in Chapter 2, all the participants in this study were university students, and although each of the participants in this group had been formally diagnosed as having dyslexia, the standard scores for the WRAT Reading and Spelling tasks for this group were equivalent to the population average, indicating that their literacy difficulties are mild in relation to other individuals with developmental dyslexia (Richardson &

Wydell 2003, Snowling et al 2001). Reading and spelling skills are of course not the only factors which are taken into consideration when a formal diagnosis of dyslexia is made, and it is perhaps not surprising that dyslexic adults studying at university would have reading and spelling performance approximately within the normal range, since individuals with much weaker literacy skills would not necessarily enter university in the first place, and dyslexics who do gain entry to university are likely to be individuals who are well practiced in reading and spelling and have had the motivation and support to work at overcoming their disability through practice and by developing compensatory strategies and so on.

So although the dyslexic group was a well-defined group, in the sense that all the dyslexics were university students (rather than a mixture of adults with different educational backgrounds/achievements), it is important to bear in mind that, as Ramus et al (2003) point out,

> "the few dyslexics who enter university are not representative of the whole population: they may be more intelligent, resourceful and socially privileged, and may have received better help with respect to reading" (p844).

For the findings of the present study to be generalised more robustly it will clearly be important to investigate the abilities of individuals with more overt reading/spelling difficulties. For the purposes of testing the Phonological Deficit Hypothesis specifically, it would also be useful to identify a group of dyslexics with an overt phonological deficit, defined in traditional terms, to establish whether dyslexics with an observable traditional phonological deficit would show difficulties with the 'representational' tasks where the dyslexics in this study (who were included whether or not they belonged to the phonological-deficit subtype of dyslexia) did not. This study was, however, very speculative in the sense that it was not known in advance what the outcome would be, and this made it less justifiable to recruit any younger individuals with dyslexia or individuals with more severe deficits. With the results of this study now available, there is now a basis on which to proceed to investigate whether these findings (i.e. the lack of a representational deficit) also generalise to other samples of the dyslexic population. It should further be noted in relation to the generalisability of the present results that the design of the study makes replication essential, since the same individuals participated in all the tasks, and thus only a relatively small number of participants was tested overall.

In terms of a developmental perspective, my results can indirectly speak to developmental issues even though my participants were all adults. As explained by Pennington et al (1990), deficits which persist into adulthood can shed light on the question of the causes of the developmental impairment, as they tend to reflect 'primary' deficits, rather than 'secondary' or 'correlated' symptoms. Primary symptoms tend to be present in all individuals with the disorder, they are observed at early stages in longitudinal studies, and, thirdly, they persist into adulthood and can be found in individuals who have otherwise compensated for the disorder. This particular study clearly cannot speak to the universality or the longitudinal priority of any of the symptoms of dyslexia, but I have shown that representational deficits, if they exist at all, do not persist into adulthood, while manipulation deficits, in line with the existing literature, including Pennington et al's (1990) study, do.

In addition to testing with individuals who have a more severe impairment in reading and spelling than this group, it would be valuable to administer these materials, and particularly the suprasegmental Interpretation materials, to younger participants. Vogel and Raimy's (2002) study of the acquisition of the compound vs phrasal stress contrast found that accuracy increased from 58% among 7 year olds up to 76% in 12 year olds, as was reviewed in Chapter 1. With the slightly different materials used in this study, and in Scotland rather than the US, it would be valuable to see whether the stress contrast is just as late acquired in Scottish English. It would also be preferable to collect data from larger samples, and with more background testing to establish the cognitive profiles of the participants more comprehensively, particularly with a view to establishing their comprehension skills.

It would furthermore be important to test how individuals with dyslexia performed if asked to carry out manipulation tasks using non-phonological information. This would help to establish how far this deficit is local to phonological units rather than a general difficulty with the segmentation and working memory demands of manipulation tasks such as spoonerisms. Units could instead be embedded in an auditory list or sequence of tones or chords, or in a visually presented geometric configuration. This would allow conclusions to be drawn on whether or not the manipulation deficit which has been found for suprasegmental information (even though it is not directly relevant for reading) transfers out of the 'phonological' domain and especially into the auditory or visual domains, and so whether the relation of the segmental manipulation deficit to reading is a "parasitical" one, or whether it is a reflection of a potentially broader, domain-general, deficit, perhaps involving working memory.

Categorical perception tasks, with stress stimuli instead of phonemes, would be one way of establishing whether any subtle perception deficit could be found in relation to linguistic categories which do not have orthographic counterparts. Although the stress phenomenon which was used in this study only has one pair of categories (fore-stress for compounds and end-stress for phrases), whereas a large number of pairs from across the phonemic inventory can be chosen in the case of segments, it is still possible to administer categorical perception tasks with just two categories. A task which would involve fewer metalinguistic demands and could again be done without recourse to orthography would be preference tasks, where participants are required to judge the goodness or appropriateness of particular stress patterns in particular contexts. The metalinguistic element of this task would consist in the need for participants to compare the given stimulus with their previous experience of similar forms, but with attention focused on the form as a whole, rather than analysing its internal components.

To tie in with the research on prosody in reading, a study could be devised in which participants would transcribe auditorily presented forms in terms of stress patterns. Again such a task would ideally make use of minimal pairs so that participants would need to rely on phonological (so-called 'quasi-phonemic') knowledge specifically. This kind of task would involve an innovated, nonce or ad hoc, writing system, which might be expected to be harder for dyslexics to master compared to non-dyslexics, but if not, it might help to distinguish between the ease of acquiring alphabetic literacy and the ease of acquiring prosodic notation systems. It would furthermore be possible to provide the segmental content of the auditory forms so that the stress information would be added by way of diacritics, for example, and if necessary include a training session (conceivably using lexical stress, and testing on minimal pairs). One prediction which arises from the Metalinguistic Hypothesis as to the relation between phonology and orthography, for instance, is that if the difference between pairs such as *ˈtoy factory* and *toy ˈfactory* did, in fact, happen to be represented in English orthography, individuals with dyslexia would be expected to be impaired in dealing with these contrasts in approximately the same way as with segmental contrasts.

6.6 Conclusion

The present study undertook to examine the *representations* element of the Phonological Deficit Hypothesis. Fundamental to the approach adopted here has been a scepticism with regard to how successfully segmental phonology can be tested as an object in its own right and independent of orthography, especially in a population which is identified to a very large extent on the basis of struggling to master literacy in an alphabetic orthography. I have been arguing that phonological representations are not provided ready-made for the child acquiring language or literacy. Diverging from some strands of contemporary thought, I have been suggesting that we should rather think of phonological representations as intrinsically and essentially shaped by our experience of living and communicating with a diverse range of other people in our societies and communities: if phonological representations exist at all, they must be conceived of as pliable, malleable things which are shaped by influences around us and our interactions with them. Key among the influences which shape us is the literateness of our society at large (a literateness which includes the social expectation that each member of the society will become literate, as well as the cognitive and educational processes by which reading, spelling, and writing skills are acquired) – an influence which has a profound effect on how our implicit mental categorisations of the patterns of the sounds of speech are shaped and modulated. From this starting point, the question of testing representations becomes one of, if not excluding, at least controlling for, orthographic knowledge, and so the issue was addressed of whether or not phonological representations would be shown to be impaired in dyslexia when the all-pervasive influence of orthography on segmental areas of phonology was excluded from the picture.

On the specific question of whether or not phonological representations are impaired in developmental dyslexia, I have been arguing that they are not. It was shown that neither the 'broad' reading of the Phonological Deficit Hypothesis nor the 'narrow' reading was able to account for the pattern of results found in the present study, since the experimental findings could not be consistently or exhaustively accounted for either on the basis of a segmental deficit which left suprasegmental representations intact, nor on the basis of a suprasegmental deficit. The findings of the Interpretation task (§2) especially tend to indicate that, in tasks which demand phonological knowledge exclusive of any links to orthography, individuals with dyslexia are unimpaired, and perform in fact at least as successfully as controls – a finding which casts a great deal of suspicion on the claims in the literature that dyslexia involves a phonological representations deficit, since it is not clear that deficits in phonology-related skills which cannot be distinguished from their connection/association with orthography are genuinely phonological. It was suggested instead that, subject to two technical caveats relating to how stress-based minimal pairs are best analysed from a phonological perspective, phonological representations in dyslexia are intact.

On the resulting question of what, then, the role of phonology in dyslexia can consist of, I argued that the well-established deficit in metalinguistic skills may very probably be the closest that a cognitive theory can come in attempting to explain the causes of the reading disability seen in dyslexia. While resisting the practice of interpreting 'phonological awareness' deficits as evidence of impairments of phonological representations, I do not dispute that these metalinguistic deficits are real, but I have argued that rather than tracing these deficits back to impaired representations, much more attention should be paid to the question of the metalinguistic nature of manipulation tasks, their artificiality in relation to communication by means of spoken language, and their reliance on an intact working memory system. Neither representations per se nor basic metalinguistic skills were impaired in the group of individuals with dyslexia tested here – it was only in the manipulation tasks that differences appeared between the two groups, bearing out what was suggested in Chapter 1, that if there is some phonology-related deficit in dyslexia, the remoter it is located from phonological representations proper, the more realistic the account is likely to be.

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Appendix B: Interpretation task materials

B.1 Materials for segmental Interpretation task

Materials for the segmental Interpretation task are drawn from the 'Minimal pair discrimination with pictures' subtask of the PALPA (Kay et al 1992). All the auditory items are drawn from the PALPA, and the visual items are a modification of the PALPA visual stimuli. They are used here with kind permission from one of the authors.

On-screen instructions

"In this task you will hear one word at a time then see two pictures. Your task is to listen to the word, then select the picture which matches the word you heard. You will hear each word once."
"First you will hear two practice examples. Listen to the word through the headphones then select the picture that matches the word. Use the 'Z' key to select the picture on the left hand side of the screen, and the 'M' key to select the picture on the right hand side."

Practice items (n = 2)

Contrast location	Auditory word	Picture combination
final	hen	hem, hen
initial	goat	goat, coat

Figure B.1. Visual counterpart for auditory *hen*

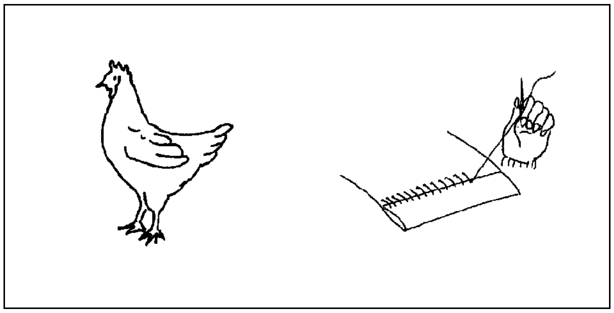
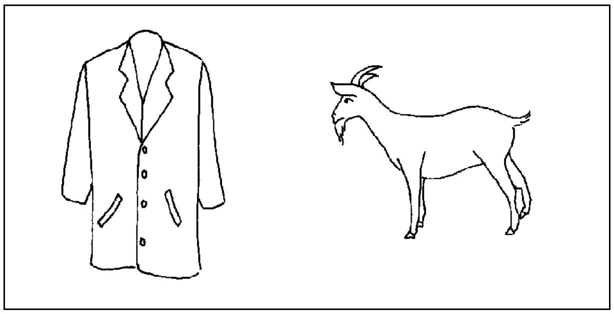


Figure B.2. Visual counterpart for auditory *goat*



Experimental items (n = 36)

Contrast location	Auditory word	Picture combination
final	back	back, bat
	bag	bag, back
	bean	bean, beam
	bud	bud, bug
	coat	coat, code
	come	cub, come
	cub	cup, cub
	fang	fan, fang
	fawn	fawn, fall
	head	hen, head
	hiss	hiss, hit
	leaf	leave, leaf
	pig	pick, pig
	rice	rice, write
	robe	road, robe
	rope	robe, rope
	run	rung, run

	tongue	tongue, tug
initial	bat bead cap cut deck dip fan feed goal gown line lip pail pill pit pole sail tack	mat, bat deed, bead cap, tap gut, cut neck, deck dip, tip fan, van seed, feed goal, coal down, gown line, nine lip, nip tail, pail bill, pill pit, kit pole, bowl tail, sail sack, tack

B.2 Materials for suprasegmental Interpretation task

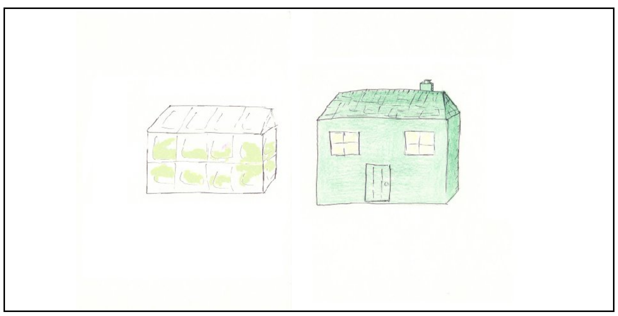
Instructions

"In this task you will hear a recording and see two pictures. The speaker will say, 'This is what a _____ looks like.' You have to select the picture which matches the sentence you heard."
"Each sentence will be played once only, and you will not get feedback on your responses."

Practice items (n = 2)

Auditory word or phrase	Possible interpretations (with matching pictures)	
	Compound interpretation	**Phrasal interpretation**
hotdog	A sausage snack	A dog which has the property of being hot
green house	A glass enclosure for growing plants	A house which is green in colour

Figure B.3. Visual counterpart for practice item *green+house*



Experimental items

Ambiguous items

Auditory word or phrase	Possible interpretations (with matching pictures)	
	Compound interpretation	**Phrasal interpretation**
baby photographer	Someone who takes photographs of babies	A baby taking photographs
German teacher	Someone who teaches German	A teacher whose nationality is German
gold hammer	A tool for hammering gold	A hammer which is made of gold (or gold in colour)
mini driver	Someone who drives a Mini	A driver who is miniature in size
orange tree	A tree which gives oranges as fruit	A tree which is orange in colour
origami man	A man who practices origami	The figure of a man made through origami
paper boat	A boat specially for transporting paper	A boat which is made of origami
pine cone	A cone from a pine tree	A conical object made from pine wood
toy factory	A factory which produces toys	A pretend factory for children to play with
wood chopper	A tool or a person which chops up wood	A chopping tool which is made of wood
wood plane	A tool for planing down wood	A plane which is made of wood

Figure B.4. Visual counterpart for ambiguous item *baby+photographer*

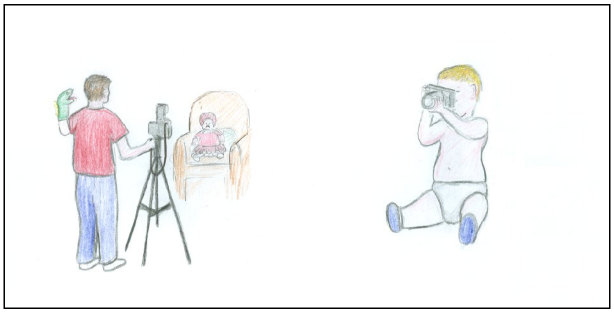
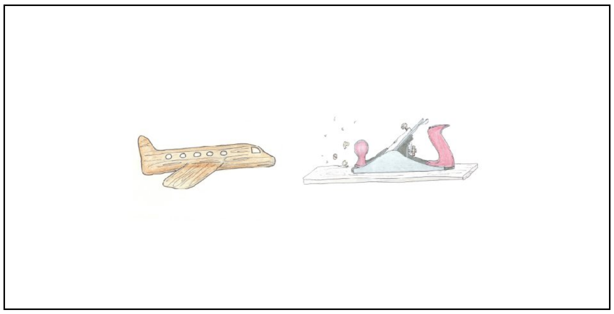


Figure B.5. Visual counterpart for ambiguous item *wood+plane*



Idiomatic items

Auditory word or phrase	Possible interpretations (with matching pictures)	
	Compound (idiomatic) interpretation	**Phrasal interpretation**
blue + bottle	The name for a type of fly	A bottle which is blue in colour
bulls + eye	The target on a dartboard	The eye of a bull
cats + eyes	Reflective road markers	The eyes of a cat
gold + fish	A type of tropical fish	An (ornamental) fish made of gold

head + hunter	Employment agent	The leader of a group of hunters
heavy + weight	Type of boxer	A weight which is heavy
high + chair	A raised chair for children to sit in at meals	A chair which has high legs
red + neck	A colloquial name for someone from the southern US states	Someone's neck which is red in colour
tight + rope	The wire which acrobats perform on	A rope pulled taut
wet + suit	The rubber suit worn by divers and surfers	A suit which is wet

Figure B.6. Visual counterpart for idiomatic item *high+chair*

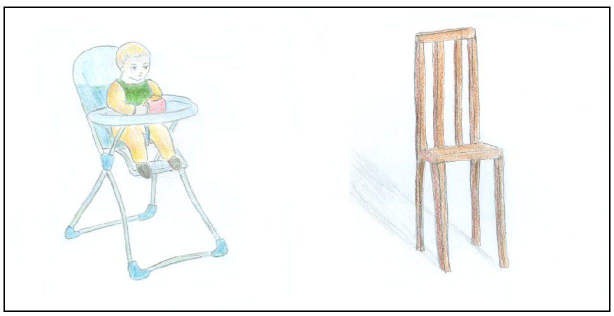
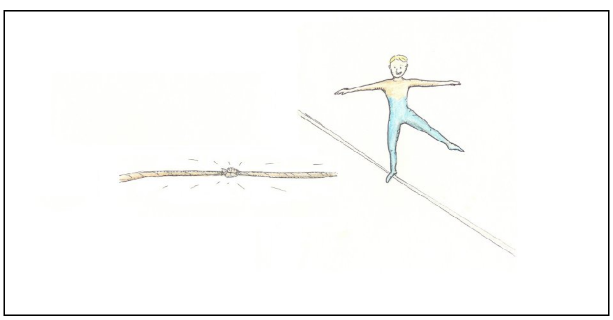


Figure B.7. Visual counterpart for idiomatic item *tight+rope*



Filler items

Item type	Auditory word or phrase	Picture combination
compound	bookstall	bookshelf, bookstall
	brake light	brake light, streetlight
	coffee cup	coffee cup, coffee pot
	milkman	milkman, frogman
	mountaintop	tabletop, mountaintop
	orange juice	orange juice, apple juice
	paperknife	paperknife, paper clip
	post box	post box, postcard
	six pack	six pack, backpack
	walking stick	walking stick, candlestick
phrase	blue boat	red boat, blue boat
	empty box	empty box, empty glass
	flat countryside	flat countryside, flat tyre
	floral curtains	floral curtains, purple curtains
	new books	old books, new books
	pasta salad	pasta salad, pasta shapes
	pink handbag	pink handbag, pink flower
	shiny bucket	rusty bucket, shiny bucket
	striped wallpaper	striped wallpaper, striped shirt
	winding river	winding river, winding street
	winter clothes	winter clothes, summer clothes

Figure B.8. Visual counterpart for filler item *pink handbag*

Appendix A: Participant details

A.1 Dyslexic group: participant details

	Age at testing	Approx age at diagnosis	Gender	Regional accent	Subject area (see key)	WRAT Reading standard score	WRAT Spelling standard score
D001	17;5	15	f	Scot	Health	95	106
D002	17;8	16	m	Eng	Sci/Eng	95	106
D003	18;9	10	f	Eng	Arts	108	110
D004	19;5	5	f	N Irish	Health	82	93
D005	20;2	--	f	Eng	Arts	92	105
D006	20;5	primary school	m	Eng	Sci/Eng	77	93
D007	20;7	primary school	f	Scot	Arts	101	103
D008	20;10	13	f	Eng	Arts	94	110
D009	21;0	--	m	Eng	Arts	103	101
D010	23;1	15	f	Eng	Arts	107	110
D011	23;4	17	m	Eng	Arts	116	103
D012	24;5	8	m	Eng	--	86	90

D013	24;7	24	f	US	Health	--	114
D014	25;1	--	f	Irish	Sci/Eng	103	104
D015	25;9	primary school	f	Scot	Health	99	104
D016	25;9	--	m	Scot	Arts	101	95
D017	28;1	27	f	Eng	Arts	103	--
D018	28;5	--	f	Scot	Arts	107	108
D019	30;6	26	m	Scot	Arts	105	95
D020	30;11	--	f	Eng	Arts	--	--
D021	41;4	40	f	Eng	Health	87	73

Key for subject area: Arts = Arts/Humanities/Social Sciences; Sci/Eng = Science/Engineering; Health = Medicine/Health Sciences

A.2 Dyslexic group: accuracy scores

	Seg Interp	Supra Interp	Seg Recog	Supra Recog	Seg PigLat	Supra PigLat	Seg Spoon	Supra Spoon
D001	1.946	0.557	2.173	0.863	2.569	0.990	1.450	-1.130
D002	2.199	0.244	1.850	0.371	1.861	1.110	1.220	1.320
D003	1.966	0.616	2.140	0.484	2.494	1.650	2.240	2.660
D004	2.175	-0.136	2.391	0.596	2.410	0.420	1.220	-0.820
D005	2.199	-0.484	1.888	0.720	2.305	1.110	0.950	1.080
D006	1.497	0.305	1.119	0.470	1.125	1.310	0.240	0.850
D007	2.180	1.692	1.620	1.458	1.623	2.050	2.670	1.580
D008	1.311	0.684	2.173	1.234	2.763	0.220	0.720	1.080
D009	2.180	0.811	1.888	1.042	2.433	-0.230	2.240	2.720
D010	2.175	1.037	2.391	-0.080	1.812	2.240	3.030	1.730
D011	2.175	1.538	2.140	0.371	3.335	1.040	2.240	2.290
D012	2.167	0.609	1.468	0.900	1.998	0.300	0.240	1.880
D013	1.966	0.743	2.169	1.458	2.795	3.010	2.240	2.300
D014	--	--	1.595	--	1.562	1.340	1.220	2.010
D015	2.199	1.573	2.391	0.912	3.508	2.210	1.260	-0.170
D016	1.948	1.378	2.140	1.990	2.521	1.790	1.510	1.340
D017	2.193	0.919	2.420	0.179	3.748	1.610	1.260	0.140
D018	2.180	1.237	1.850	0.720	2.999	3.400	2.600	--
D019	2.175	1.125	1.922	-0.080	3.197	1.310	0.720	0.110
D020	2.199	1.333	2.391	0.595	3.110	1.210	2.600	2.300
D021	1.496	-0.305	1.662	0.170	--	--	-0.990	-1.550

A.3 Dyslexic group: response times

	Seg Interp	Supra Interp	Seg Recog	Supra Recog	Seg PigLat	Supra PigLat	Seg Spoon	Supra Spoon
D001	1961	2801	176	496	562	508	887	981
D002	1458	4436	524	724	703	837	926	4954
D003	2384	2746	499	1161	876	2108	1503	1049
D004	2010	2302	409	670	963	1046	1248	726
D005	1318	3999	589	981	2184	2160	1866	2458
D006	1830	6498	3313	671	2050	1267	1998	1536
D007	2451	3961	591	1192	1537	1772	841	1788
D008	953	2054	408	461	949	489	1436	925
D009	1239	3664	739	2132	2153	5355	667	520
D010	1112	4354	371	1980	1804	1886	3618	1394
D011	2034	2531	405	1540	1207	1209	713	533
D012	1424	4304	774	1380	4559	4987	3343	2165
D013	2063	3712	263	399	854	4160	1938	615
D014	--	--	1217	--	2484	3320	1399	772
D015	2067	3068	374	625	844	1732	1976	6261
D016	2132	4099	1148	1269	1719	2785	1380	1190
D017	1972	5315	667	2108	4211	4213	4099	517
D018	2068	2095	257	1154	1558	913	1348	--
D019	2194	3854	777	1923	1488	2693	1965	1189
D020	1995	2819	362	2082	777	1024	1214	1203
D021	1979	4539	1029	940	--	--	952	854

A.4 Control group: participant details

	Age at testing	Gender	Regional accent	Subject area	WRAT Reading	WRAT Spelling
C001	17;6	f	Scot	Arts/Humanities/ Social Science	110	107
C002	23;2	m	Eng	Arts/Humanities/ Social Science	103	105
C003	18;6	f	Scot	Arts/Humanities/ Social Science	97	112
C004	19;11	f	Eng	Arts/Humanities/ Social Science	115	106
C005	19;11	f	Eng	Arts/Humanities/ Social Science	106	104
C006	21;10	m	Eng	Science/Engineering	114	112
C007	20;8	f	Scot	Arts/Humanities/ Social Science	99	104
C008	22;3	f	Eng	Arts/Humanities/ Social Science	109	106
C009	20;3	m	Eng	Arts/Humanities/ Social Science	114	103
C010	22;7	f	Eng	Arts/Humanities/ Social Science	118	103
C011	23;3	m	Eng	Arts/Humanities/ Social Science	105	108
C012	24;5	m	Eng	Arts/Humanities/ Social Science	109	118
C013	21;1	f	US	Science/Engineering	99	116
C014	19;10	f	N Irish	Science/Engineering	117	114
C015	26;7	f	Eng	Arts/Humanities/ Social Science	107	119
C016	26;5	m	Eng	Science/Engineering	105	118

C017	24;4	f	Eng	Science/Engineering	109	112
C018	28;2	f	Eng	Arts/Humanities/ Social Science	114	108
C019	28;11	m	Canadian	Arts/Humanities/ Social Science	107	116
C020	34;2	f	Eng	Arts/Humanities/ Social Science	116	112
C021	42;5	f	Canadian	--	92	110

A.5 Control group: accuracy scores

	Seg Interp	Supra Interp	Seg Recog	Supra Recog	Seg PigLat	Supra PigLat	Seg Spoon	Supra Spoon
C001	2.193	1.378	2.391	1.722	3.697	1.560	3.380	2.640
C002	2.160	1.763	1.880	0.912	2.485	1.180	2.300	3.070
C003	1.940	0.245	2.388	0.675	2.966	1.220	2.600	1.500
C004	1.940	1.538	2.140	1.769	3.416	3.720	3.030	3.420
C005	--	-0.177	2.141	-0.358	2.990	1.690	3.030	1.880
C006	2.180	1.692	2.388	2.026	3.399	3.010	1.450	2.080
C007	1.946	0.705	1.628	-0.278	3.493	1.030	1.940	1.080
C008	2.460	1.418	2.173	-0.416	3.665	2.040	3.030	3.070
C009	1.702	0.625	2.173	-0.192	2.585	2.080	2.600	3.420
C010	1.924	2.014	2.173	2.290	3.717	2.780	2.670	2.370
C011	2.193	1.084	2.420	-0.774	3.391	1.560	2.600	1.880
C012	2.193	1.733	2.420	2.290	3.658	3.010	2.240	3.420
C013	1.523	-0.059	1.640	0.305	3.135	-0.720	1.680	0.600
C014	1.966	1.244	2.131	1.468	2.984	3.400	2.300	3.420
C015	1.948	1.105	2.420	0.278	2.882	1.680	1.940	0.560
C016	2.175	1.157	1.820	0.900	3.723	2.320	1.820	3.070
C017	2.217	1.085	1.383	1.534	2.512	1.410	2.300	1.990
C018	1.946	1.237	2.173	1.211	3.559	2.680	2.600	3.420
C019	2.199	-0.136	2.173	0.550	2.841	0.230	1.680	0.540
C020	2.175	1.282	1.922	0.000	3.665	1.530	3.380	1.320
C021	1.783	0.000	2.140	0.900	2.175	0.290	1.940	1.570

A.6 Control group: response times

	Seg Interp	Supra Interp	Seg Recog	Supra Recog	Seg PigLat	Supra PigLat	Seg Spoon	Supra Spoon
C001	1256	3774	591	1100	700	2710	1110	953
C002	1472	7012	1610	1908	2924	4142	4016	2500
C003	1172	2645	648	775	1250	1586	852	1380
C004	1205	3839	566	1306	449	2242	1333	2801
C005	--	3457	551	690	536	565	1056	962
C006	2833	5843	785	1760	457	1908	2497	1028
C007	1004	2979	599	1238	1675	1176	2308	920
C008	1938	2411	231	593	426	396	442	2158
C009	2444	3802	696	1508	541	1794	1194	2027
C010	2185	3943	328	793	680	1415	1626	1047
C011	2145	4323	757	1287	656	901	1001	1526
C012	2680	5949	468	1395	1689	2580	3122	1077
C013	2621	5091	837	1075	1615	1529	3375	2267
C014	2110	3508	580	1815	446	1940	994	1599
C015	2240	3752	704	712	1114	1197	1560	822
C016	1745	4764	518	2460	490	1608	2499	1105
C017	2181	3491	414	1445	1425	833	1284	2108
C018	1975	2558	385	1112	556	1237	1009	6061
C019	1245	3337	890	3096	1225	4005	2545	2371
C020	986	5420	334	2126	1573	4650	4703	1338
C021	1435	4857	419	869	662	755	1052	1173

Appendix C: Recognition task materials

C.1 Materials for segmental Recognition task

Verbal instructions

A spoken version of the on-screen instructions was discussed with each individual participant prior to running the E-Prime script. This made it possible to ascertain that each participant expressed their understanding of what the task involved, prior to participating in the task. It was explained that the task involved listening to pairs of words in order to identify which word in the pair contained a particular sound, which they would be told about at the start. To start with the participant would hear a pair of sample words which would demonstrate which sound they should listen out for. The words *man* and *meet* were used as an example of the sample pair, and participants were told that the first sound of these words, which was common to both words, was the sound they should listen for. They were then told that they would hear pairs of words (such as *father* and *mother*), and that in this case they should indicate that it was the second word which contained the sound /m/ which they were listening for.

On-screen instructions

"In this task you will hear two words at a time through the headphones. You will be told to listen for a particular sound. Your task is to indicate whether that sound occurred in the first word that you heard, or the second."
"You will hear each pair of words once only. Use the 'Z' key to say that it was the first word, and the 'M' key to say that it was the second word. There are two parts to this task. You will be asked to listen for a different sound in each part. The speaker will now tell you which sound to listen for in this part of the task."

Auditory instructions

"Think about the first sound in the word *ten*. It's the same as the first sound in the word *time*. Now listen for this sound in the words which follow."
"Think about the first sound in the word *sing*. It's the same as the first sound in the word *soft*. Now listen for this sound in the words which follow."

Experimental items (n = 24)

Location of target segment	**Minimal pairs based on /t/**	**Minimal pairs based on /s/**
medial	beater, beaker cattle, cackle sleety, sleepy water, walker	fussy, fuzzy gristle, grizzle muscle, muffle useful, youthful
final	await, awake civet, civic * limpet, limpid * sonnet, sonic *	bypass, bypath malice, mallet * penance, pennons * release, relief
cluster	buster, busker extend, expend musty, musky streaming, screaming	listed, lifted musty, mufti slipper, flipper unslung, unflung

The asterisk (*) marks the items where the contrast was located in the unstressed syllable.

C.2 Materials for suprasegmental Recognition task

Verbal instructions

A spoken version of the on-screen instructions was discussed with each individual participant prior to running the E-Prime script. It was explicitly pointed out to participants that the difference between *hotdog* and *hot dog* was in the way that they were stressed – there was both the *'hotdog* pattern, or the DA-da pattern, and the *hot 'dog*, or da-DA, pattern. Participants were told that in this task they would listen out for one or the other of these patterns; they would be given a list of pairs of words, and they should indicate which of the two items in the pair contained the sound they were listening out for.

On-screen instructions

"This task is about listening out for the stress patterns of words and phrases. You can think of the 'stressed' part of a word or phrase as the part which has the most emphasis, or prominence. You will hear two words or phrases at a time. One of them will have the main stress at the start, and the other one will have the main stress towards the end."
"After you have read this screen you will hear a couple of examples. In the first example, the main stress (or emphasis) is at the start of the word. You will then hear an example where the main stress is located towards the end. Press any key to hear this pair of items."
"Check that you can hear the main stress at the start, followed by main stress towards the end. In the first part of this task, you have to listen for items where the main stress falls at the START, not the end, of the item."

"Well done! You are now half way through the task. So far you have been listening out for stress at the start of the item. But for the remaining pairs of items, your task changes. Instead, your task is to listen for stress at the END of the item."

(Note that these were the instructions for listening for compound stress in the first half of the task, followed by phrasal stress in the second half of the task. The instructions were modified appropriately for the participants who did the task in the opposite order.)

True minimal pairs (n = 12, plus 2 practice items)

Ambiguous items	Idiomatic items
(practice) cylinder connector	(practice) light + house
cardboard shop	black + belt
child murderer	black + bird
female assassin	gold + digger
glass case	green + belt
Latin lover	lamb + chops
metal separator	red + coat
navy flag	white + house
patient queue	white + wash
plastic knife	
plywood warehouse	
steel cable	
steel warehouse	

Note that the interpretations of these items (under the two different stress patterns) are not listed here, as it was not necessary for the participants to be able to assign an interpretation to the sounds that they heard (the meaning of the words and phrases was not relevant for carrying out the task successfully).

Near minimal pairs (n = 20)

Shared element	Fore-stress	End-stress
Word1	apple juice	apple pie
	briefcase	brief chase
	chocolate cake	chocolate egg
	lorry driver	expert driver
	grandmother	grand master
	headache	head chef
	magic maker	magic number
	narrow boat	narrow street
	seawater	salt water
	stonework	stone wall
Word2	bargain hunter	bigger hunter
	beauty treatment	better treatment
	birthday party	office party
	light house	light brown
	milk bottle	chilled bottle
	pickpocket	back pocket

	public house	public health
	swivel chair	special chair
	toothpaste	blue paste
	phone number	wrong number

Appendix D: Pig Latin task materials

D.1 Materials for segmental Pig Latin task

Verbal instructions

A spoken version of the on-screen instructions was discussed with each individual participant prior to running the E-Prime script. The word *skipper* was used as a sample to talk through the modification procedure, then participants were given *black* as a practice word which they pig latinised verbally in response. If they wanted a second practice item they were given *card*.

On-screen instructions

"The modification procedure is as follows. The word should have its very first sound chopped off and moved to the end of the word. When that sound is at the end of the word, it should be attached to the sound 'ey' to make a new syllable. Note that after the modification, the result will not always be a real English word."

Practice items (n = 2)

baby
blender

Experimental items (n = 35)

The four foil types were drawn from Pennington et al (1990), and are identified in the table as follows:

- A: 'addition' foils, such as *blanket-bey*
- O: 'omission' foils, such as *lanket-ey*

- N: 'non-segmentation' foils, such as *blanket-ey*
- C: 'cluster' foils, such as *anket-bley*

Modification type	Singleton onset	Biconsonantal onset	Triconsonantal onset
Correctly Pig Latinised	habit (abit-hey) lady (ady-hey) leather (eather-ley) rabbit (abbit-rey) sudden (udden-sey) weather (eather-wey)	braver (raver-bey) closet (loset-kay) dragon (ragon-dey) dresser (resser-dey) flatten (latten-fey) platter (latter-pey)	screamer (creamer-sey) splatter (platter-sey) splendid (plendid-sey) splinter (plinter-sey) stranger (tranger-sey) stronger (tronger-sey)
Foil	feather (O) funny (A) happen (A) kitten (O) mitten (O)	blanket (O) brother (O) cleaner (A) driver (O) drummer (A) flatter (A)	scraper (C) splitting (N) strainer (N) strangle (N) streamer (C) struggle (C)

D.2 Materials for suprasegmental Pig Latin task

Verbal instructions

A spoken version of the on-screen instructions was discussed with each individual participant prior to running the E-Prime script. The word *dragon* was used as a sample to talk through the modification procedure, then participants were given *rabbit* as a practice word which they pig latinised verbally in response. The word *booklet* was given as a second practice item if necessary.

On-screen Instructions

"The modification procedure is as follows. The word which you hear first will consist of three syllables. One of the syllables will be more prominent (or have more emphasis) than the others. You can think of it as having the word's 'main stress.' The main stress of the word should be moved one syllable closer to the end of the word. Then an extra syllable should be added at the end, giving the word four syllables altogether. The extra syllable will always be ‘ta-‘.”

Practice items (n = 2)

selective
thesaurus

Experimental items (n = 34)

There were three types of foil, marked in the table below as follows:

- S: stress remains in the same place, eg *'ca.len.dar-ta*
- E: (for SWW items) stress moves two places towards the end rather than one place, eg *ca.len.'dar-ta*
- B: (for WSW items) stress moves backwards rather than forwards in the word, eg *'dog.ma.tic-ta*

Modification	Items with SWW pattern	Items with WSW pattern
Correctly Pig Latinised	ãbroccoli (broãccoli-ta) ãcalendar (caãlendar-ta) ãfactory (facãtory-ta) ãfurniture (furãniture-ta) ãgraduate (graãduate-ta) ãhexagon (/h□kãsag□n-ta/) ãmagistrate (maãgistrate-ta) ãregular (/r□gãjulŮr-ta/) ãsurgery (surãgery-ta)	caãthedral (catheãdral-ta) diãmension (dimenãsion-ta) flaãmingo (flaminãgo-ta) conãsumer (consuãmer-ta) harãpooner (harpooãner-ta) meãchanic (mechaãnic-ta) progãnosis (prognoãsis-ta) reãvision (reviãsion-ta)
Foil	daffodil (E) functional (E) membership (E) wilderness (E) duplicate (S) fisherman (S) lunacy (S) stamina (S) victory (S)	curator (B) memento (B) robotic (B) safari (B) dogmatic (S) forensic (S) procedure (S) proposal (S)

Appendix E: Spoonerism task materials

E.1 Materials for segmental Spoonerism task

Verbal instructions

A spoken version of the on-screen instructions was discussed with each individual participant prior to running the E-Prime script. The pair of words *lazy* and *dog* was used as a sample to talk through the modification procedure, then participants were given *king* and *ball* as a practice pair which they spoonerised verbally in response. The pair *blue* and *car* was given if a second practice item was necessary.

On-screen Instructions

"The modification should be done as follows. Each of the two original words should have their first sounds removed. Then the first sounds should be swapped round and re-attached to the opposite word. Ie, the first sound of the first word becomes the first sound of the second word, and vice versa."

Practice pairs (n = 2)

marble, volume
salad, powder

Experimental pairs (n = 22)

There were three types of foil, marked in the table below as follows:

- Con1 and Con2: (for the items with singleton onsets) only the initial consonant of the first or second word respectively was replaced, eg *plastic*, *craggy* becomes *plastic*, *praggy*

- Clus: (for the items with biconsonantal onsets) the whole cluster of each word was exchanged, eg *crastic*, *plaggy*
- Syll: the whole syllable was exchanged, eg *ham.ster*, *sig.nal* becomes *ham.nal*, *sig.ster*

Modification type	**Singleton onset**	**Biconsonantal onset**
Correctly Spoonerised	beckon, sandal (seckon, bandal) fashion, noble (nashion, foble) feather, serpent (seather, ferpent) lantern, kitten (kantern, litten) puffin, legend (luffin, pegend) saddle, baby (baddle, saby) secret, ribbon (recret, sibbon)	clinic, prison (plinic, crison) klaxon, brandy (blaxon, krandy) planter, grovel (glater, provel) plastic, craggy (clastic, praggy)
Foil	parsnip, visit (Con1) random, tulip (Con1) verdict, double (Con2) weapon, tinder (Con1) cabbage, motor (Syll) hamster, signal (Syll)	glutton, proxy (Clus) twenty, gravy (Clus) clover, spirit (Syll) tractor, scalpel (Syll) trumpet, blazer (Syllable)

E.2 Materials for suprasegmental Spoonerism task

Verbal instructions

A spoken version of the on-screen instructions was discussed with each individual participant prior to running the E-Prime script. The pair of words *bamboo* and *carpet* was used as a sample to talk through the modification procedure, then participants were given *sardine* and *dragon* as a practice pair which they spoonerised verbally in response. The pair *giraffe* and *combat* was used if a second practice pair was necessary.

On-screen Instructions

"The instructions are as follows. Both the words will have three syllables, but they will have different stress patterns. They should be modified so that the stress pattern of the first word becomes the stress pattern of the second word, and vice versa."

Practice pairs (n = 2)

octagon, majestic
orthodox, inventor

Experimental pairs (n = 23)

There were two types of foil, marked in the table below as follows:

- S1 and S2: stress remained in the same place on the first or second of the items respectively, eg *ca'the.dral*, *'bad.min.ton* becomes *'ca.the.dral*, *'bad.min.ton*
- E1 and E2: stress moved to the end of the first or the second of the items respectively, eg *ca.the.'dral*, *bad.'min.ton*

Modification	**SWW-WSW pairs**	**WSW-SWWpairs**
Correctly Spoonerised	ãcrocodile, disãclaimer (croãcodile, ãdisclaimer) ãfictional, preãtender (ficãtional, ãpretender) ãlegacy, sarãcastic (leãgacy, ãsarcastic) ãnitrogen, coãnundrum (niãtrogen, ãconundrum) ãpractical, tranãsistor (pracãtical, ãtransistor) ãtelescope, volãcano (teãlescope, ãvolcano)	caãthedral, ãbadminton (ãcathedral, badãminton) draãmatic, ãplasticine (ãdramatic, plasãticine) elecãtric, ãsceptical (ãelectric, scepãtical) equipment /iãkw□pmŮnt/, ãpedantry (ãequipment, peãdantry) fiãasco, ãtricycle (ãfiasco, triãcycle) fraãternal, ãresident (ãfraternal, reãsident)
Foil	cardigan, November (S2) gallantry, persona (S2) harvester, spectator (S1) spatula, credentials (S1) tornado, cranberry (S1)	defender, magnitude (E1) explosive, aerodrome (E1) flamboyant, stalagmite (E2) frivolous, harmonic (E1) horizon, wilderness (E2) stimulant, potato (E2)